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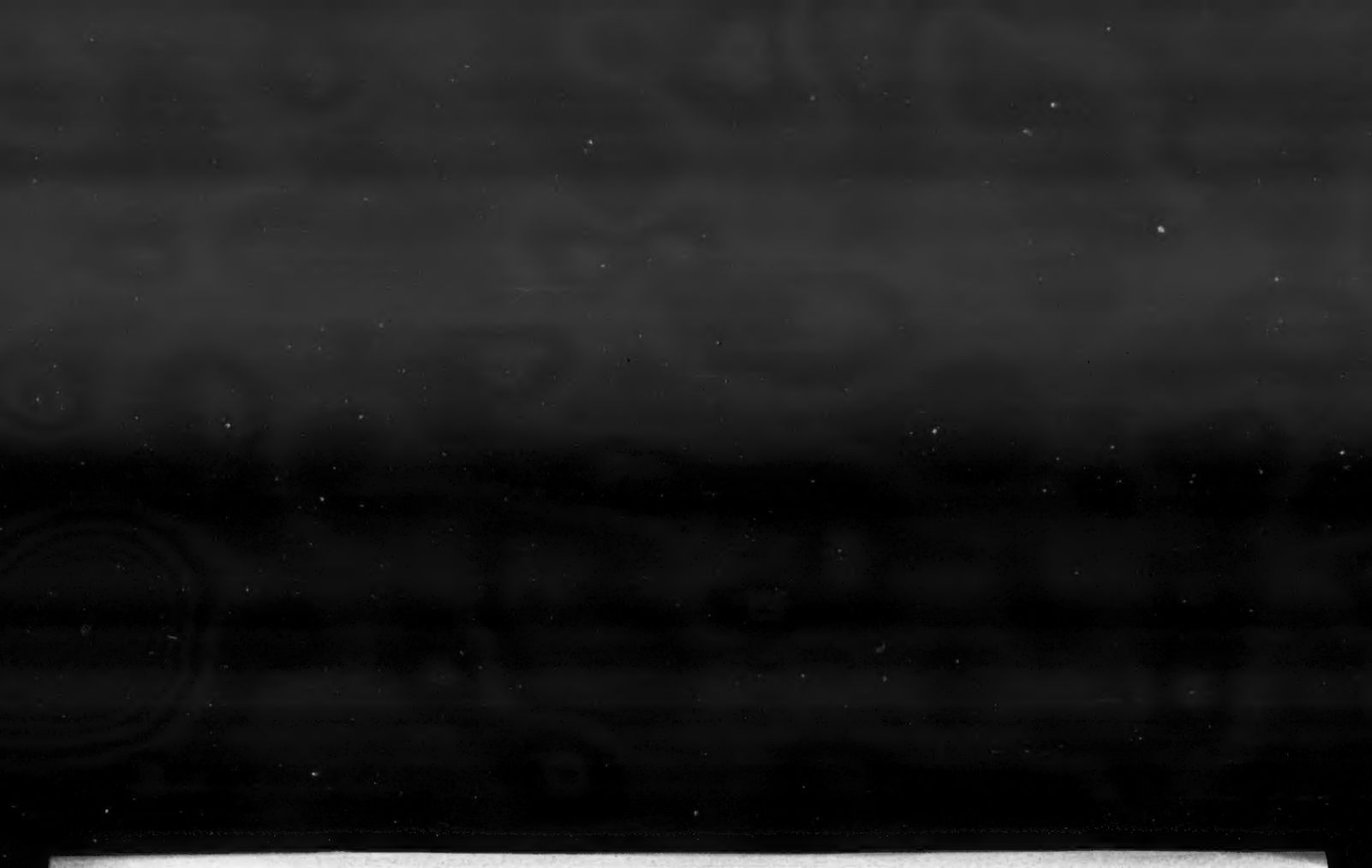


THE

AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

ART. XXX.—*The Bolometer;* by S. P. LANGLEY.

IN the number of this Journal for March, 1881, there appeared an article descriptive of the actinic balance (since called the Bolometer), an instrument which has gained acceptance among physicists as a useful aid in the study of radiant heat. It was, it may be remembered, originally devised by the writer to discriminate the heat in any small portion of the grating spectrum, but it has since found wider applications.

As at first constructed, the strips, representing arms of the Wheatstone bridge, were made of iron from 0·001 to 0·0001 of an inch in thickness. The instrument was even under these initial conditions, very many times as sensitive as the best thermopile the writer then possessed, but there does not appear to be any definite statement as to the exact sensitiveness in its early form.

In the article referred to, however, the instrument is represented as giving a deflection of about 40 scale divisions (millimeters) from the lunar heat, concentrated by a thirteen-inch lens, and it was sufficiently accurate to give a probable error of rather less than one per cent for a single observation on a constant source of heat, so that the accuracy of the bolometer (quite a distinct consideration from its sensitiveness) was even then as great as that of the best photometric process. The galvanometer in use at that time was one of the early Thomson pattern made by Elliott.

The first bolometers were made by the writer's own hands. Subsequently the strips were usually cut out from sheets of thin platinum, and in one or two instances made from flatted wire, the strip of the linear bolometer at that time (about 1883)

being usually about 10 millimeters long; anywhere from 0·001 to 0·01 of a millimeter thick, and, according to its special purpose, being made from 1 millimeter to 0·1 millimeter wide.

About 1886 the mounting of the instrument had been improved by the writer, so that the strip appeared like the vertical "wire" of a reticule in the focus of a positive eye-piece. It was also movable in some cases by a micrometer screw, and was, in fact, a micrometer thread controlled in the usual way, but endowed with the special power of feeling the radiations from any object on which it was directed.

In the earliest spectrum work the bolometer developed another important quality, its "precision." This quality is quite independent of the accuracy with which it repeats measures of radiation or any constant source of heat, and concerns the precision of setting, as a micrometer thread. It could even twelve years ago, be pointed, not only like the thermopile, within a fraction of a degree of the place of the source of radiation, as for instance on a bright line in the spectrum, but within a fraction of a minute of arc.

The instrument of course depends for its general efficiency on the galvanometer with which it is connected. That used in 1886* had several improvements due to the suggestions of Sir William Thomson and Professor Rowland, and was, perhaps, at that time, the most effective instrument of its kind in use for such a purpose, the mirror and needles having been specially constructed at the Allegheny Observatory. The mirrors were platinized by the kindness of Professor Wright, and were at that time nearly a centimeter in diameter. The needles were hollow magnets made by Mr. Very of the Allegheny Observatory. For the damping mechanism of the older galvanometer, I had substituted a dragon-fly (*Libellula*) wing, in which nature offers a model of lightness and rigidity quite inimitable by art. At that time, when making a single vibration in 20 seconds, a deflection of one millimeter division of the scale at one meter distance was given by a current of 0·000,000,0005 amperes, the instrument as described being capable of recording a change of temperature in the bolometer strips of less than 0·00001 of a degree centigrade. So much less than this could be observed by special precaution, that it might be said that this one one-hundred-thousandth of a degree was not only indicable but measurable by the apparatus, which was employed as described, in the determinations of the relations of n to λ for the rock salt prism, and by which the infrared spectrum was at that time followed by actual measurement, to a wave-length of rather over five one-thousandths of a millimeter.

*This Journal, 3d series, vol. xxxii, page 90, 1886.

Since then the bolometer has been used in various researches, of which some occasional account has been given in this Journal. (See numbers for November, 1888, and August, 1890.) During recent years it has been specially employed in making a bolographic map of the lower spectrum, the publication of which has been greatly delayed by conditions incidental to the relations of the Smithsonian Observatory with the Government, but which it is hoped will not be deferred much longer.

Without here entering into an account of the work done by it, I have thought that it might be of interest to give very briefly a statement of the present condition and form of the instrument itself, considered under three aspects:

1. Its precision, or the degree of exactitude with which it can be set on a special point, as, for instance, on a line of the invisible spectrum, recognized by its heat radiation alone.

2. Its accuracy, or its capacity for repeating the same measure of radiation under like conditions.

3. Its sensitiveness, or capacity for detecting minute radiations.

The instrument which I will take as the subject of comparison with the earlier one as described in this Journal (August, 1886), is now in use in a chamber automatically kept at a temperature, constant within one-tenth of a degree centigrade.

The strips, the essential part of the instrument, are in the present case made by Mr. C. G. Abbot, and are of platinum, the central one being rather less than 0·1 of a millimeter wide. (The case is now made of metal instead of ebonite, and is surrounded by a current of water.)

It is quite possible to make bolometer strips much narrower, but this is less necessary with the employment of the long-focus, image-forming mirror, so that in the present case the strip is at such a distance that it subtends an angle of 3·4 seconds. Its angular aperture is in practice adapted to that of the slit, which, with the use of the long collimator employed by the writer, gives a capacity of pointing (pointing, that is, *in the dark*), with a probable error of little over a second of arc. Quite recently, owing to the use of a novel collimating system of two cylindrical mirrors proposed by Mr. Abbot, the slit, though at a moderate distance, can have an opening sufficient to avoid prejudicial diffraction effects, while subtending an angle of considerably less than one second of arc.

In the galvanometer, the use of the fine quartz threads and specially small mirrors, originally due to Mr. Boys, has lately been carried to what seems near the practicable extreme, the quite invisible thread being made some 30 centimeters long, the mirror 2 millimeters in diameter, and weighing but 2 milli-

grams, and its six needles, of proportionate weight and dimensions.

This system is now made to serve with a much shorter swing than that formerly employed. If we reduce it to a time of single vibration of 20 seconds, only for the purpose of comparing it with the values already given in the earlier form, we obtain the results submitted below.

Before giving them, however, it is to be mentioned that the apparatus at Washington is most unfavorably situated, owing to its being subject to tremor from the traffic of neighboring streets and to other causes, which it has been the object of years of struggle to conquer. This has been so far done that the values presently to be given (which, it will be remembered, are only attainable in a chamber of constant temperature, with special precaution against disturbance from external tremor), can be counted on as real values, always obtainable under proper conditions, and, in fact, rather within than without the average working capacity of the instrument.

I here consider the bolometer as at present employed.

(1) With regard to its precision, or exactness of pointing. The old thermopile could be set on a portion of the spectrum only with an error of a considerable fraction of a degree. The linear bolometer as employed in 1886 could be set with a probable error of a fraction of a minute of arc. The bolometer as employed to-day, and moved through the spectrum by clockwork, can be automatically set with a probable error of a single observation of little over a second of arc, can be set, that is, in the dark with a precision little inferior to the capacity of the eye in setting a micrometer thread in the light.

(2) As to its accuracy. I have had occasion recently to take a series of measures of successive throws of the galvanometer, using as a source of heat an Argand petroleum flame in a common student's lamp. I had no photometer at hand, but taking the usual statements of the text books as to the accuracy of vision, it might be expected that such measures with the eye would give a probable error of about one per cent. (This is where sources of light of similar quality are compared.) The probable error of a single galvanometer reading was between 0·03 and 0·04 of one per cent., and this included the fluctuation of the intensity of the source of radiation, and the error of estimating tenths by the reader on the scale, both quantities of nearly the same order as the error in question. It seems safe to say, then, that *no* error attributable to inaccuracy of the bolometer could be detected by the means employed.

(3) As to sensitiveness. In the early work, for a time of single swing of 20 seconds, a deflection of one millimeter with

the scale at a meter's distance was obtainable with a current of 0·000,000,000,5 of an ampere. At present, under such circumstances, a similar deflection would be obtained with 0·000,000,000,0012 ampere, that is to say, the apparatus is about 400 times as sensitive as it was when first described.

At present, the bolometric apparatus under the conditions already cited, will indicate a change of temperature in its strips of at any rate much less than one-ten-millionth of one degree centigrade.

Smithsonian Institution, Washington, Feb. 1898.

ART. XXXI.—*On the Temperature Coefficients of Certain Seasoned Hard Steel Magnets;* by ARTHUR DURWARD.

IN a paper* published last year, Prof. B. O. Peirce gave the induction coefficients of a large number of glass-hard magnets made of different kinds of steel and carefully seasoned in the manner described† by Messrs. Barus and Strouhal. These magnets being at my disposal, it seemed to me that a series of measurements of their temperature coefficients might yield interesting results, since it is often desirable to know the comparative effects of slight changes of temperature upon the moments of magnets of different shapes used in determining the strengths of magnetic fields. I had not been able to discover that any one else had experimented upon so large a variety‡ of stout seasoned magnets, and I hoped that the results might be sufficiently uniform to indicate some relation connecting the temperature coefficients of such magnets, made of a given kind of steel, with their dimensions. Some of the tables printed below show very approximately what this relation is for certain brands of steel. The temperature coefficients of two magnets of the same dimensions and material, however, sometimes differed so widely that the results did not seem capable of any very definite interpretation. This was especially true in the case of a large set of magnets made of twice

* This Journal. November, 1896.

† Bulletin of the U. S. Geological Survey, No. 14, 1885.

‡ L. Dufour, Pogg. Ann., xcix, 1855; Holmgren, Acta Soc. Scient. Upsala, 3, i, 1856; Gore, Phil. Mag. (4), xl, 1870; Unverdorben, Inauguralschrift, 1866; Gordon and Newhall, Phil. Mag. (4), xlii, 1871; Marshall, Proc. Edin. Soc., vii, 1873; Jamin, Moudes, 2, xxxiii, 1873; Wild, Carl's Repert., ix, 1873; Favé, Comptes Rendus, lxxxii, 1876; Gaugain, Comptes Rendus, lxxxii; Poloni, Naturforscher, xiii, 1880; Trowbridge, this Journal, 1881; Poloni, Beiblätter, v, 1881; Poloni, Journ. de Physique, 2, ii, 1883; F. Kohlrausch, Wied. Ann., xxii, 1884; Berson, Journ. de Physique, 2, v, 1886; Ledeboer, Journ. de Physique, 2, vii; Chistoni, Mem. Modena, 2, ix, 1893; Cancani, Atti. Acc. Lincei, 1887.

hardened steel, where some abnormally large temperature coefficients were explained by the fact that the steel proved to be soft in places. Local softness is very difficult to avoid in re-hardening steel rods which have once been made glass-hard, and one must expect to find that an occasional specimen of once hardened steel is soft in places.*

If great accuracy is required it is of course necessary to determine the coefficients of a given magnet by direct experiment, but the average of determinations made on a number of magnets of a certain size seems to show very approximately what may be expected of normal specimens.

The straight bar magnets experimented on were of several kinds of steel, and varied in length from 3^{cm} to 20^{cm}. Most of them were circular cylinders, though there were about 40 of rectangular cross section and a few were what are commonly called "hollow cylinders." All had been heated to a cherry red in a special gas heater, then immersed in a large tank of rapidly stirred, acidulated or salted, ice water, and finally exposed for a long time to a temperature of 100° C. After the rods, which were still glass-hard, had been magnetized to saturation between the poles of a soft iron yoke in a long solenoid, they were again exposed for hours to the temperature of boiling water. After standing for several months, most of the magnets were reboiled, re-magnetized in the same direction as before, and then boiled again. In some cases this process was repeated several times.

Besides a number of twice hardened magnets, and a few bar magnets of rectangular cross section, I tested nearly 120 round, straight magnets made of once hardened tool steel, from $0{\cdot}32^{cm}$ to $1{\cdot}11^{cm}$ in diameter. I am indebted to Prof. B. O. Peirce, and also to Mr. C. G. Persons of the staff of the Jefferson Physical Laboratory, for additional tests made on about 200 magnets.

It was desirable first to find out how nearly constant the temperature coefficients of such magnets are between ordinary room temperatures and 100° C. To test this the magnet to be experimented on was mounted horizontally in a non-magnetic holder, fixed in a wooden tank, so as to be in Gauss's A position with reference to a mirror magnetometer which rested on a stable support of its own. The tank could be moved eastward or westward on a track and could be clamped to the track if desired. Its distance from the magnetometer could be accurately adjusted by the help of a slow motion screw. By means

* The permanent magnetic moment of one of two hollow magnets made by a well known firm of instrument makers for use in the Jefferson Physical Laboratory, and supposed to be as nearly alike as possible, proved to be nearly twice as great as that of the other, and this difference was due to difference in hardness.

of non-magnetic steam and cold water pipes, furnished with suitable valves and connections, the tank, which had a good stirring apparatus, could be filled with about 15 liters of water at any required temperature from about 15° C. to 100° C.

On the opposite side of the magnetometer was a seasoned compensating magnet in Gauss's A position, held, and protected completely from rapid temperature changes, within a wooden carriage sliding on a horizontal scale. This compensating magnet having been placed with its center at a convenient distance (d_0) from the center of the magnetometer needle, the tank, filled with water at nearly the temperature of the room, was fixed at such a distance from the magnetometer as to bring the needle back into the meridian. If M_0 is the magnetic moment of the compensating magnet and $2l_0$ its magnetic length, and if M_1 is the moment of the magnet to be tested and M_1' its moment when, having been heated to a higher temperature, the needle is deflected so as to cause a scale reading n with a scale distance a,

$$\frac{M_1 - M_1'}{M_1} = \frac{Hn}{M_0} \cdot \frac{(d_0^2 - l_0^2)^2}{4ad_0}.$$

If α_0 is the angle through which M_0 would deflect the needle if M_1 were absent,

$$\frac{M_1 - M_1'}{M_1} = \frac{n}{2a \tan \alpha_0}$$

The method of procedure was then as follows: The compensating magnet was placed at a given fixed distance from the magnetometer, the magnet to be tested clamped in the non-magnetic holder in the tank, and cold water turned in. The position of the wooden tank was then adjusted until the needle showed its original zero reading. Steam was then passed in at intervals and deflections taken at various desired temperatures up to 100°, the positions of both magnets remaining unchanged throughout the process. The dimensions and the magnetic moment of the compensating magnet being known, the fractional loss of moment of the magnet to be tested could be easily calculated from the formula given above. With this apparatus I tested about 25 magnets; additional magnets were tested for me in a similar manner by other observers. The total number tested was sufficient to determine with some degree of certainty how much the curve of variation of magnetism differed from a straight line.

It appeared in the first place that among the magnets which had not been heated above room temperature for a long time, some did not regain their original strengths immediately after being heated to 100° C. and then cooled to room temperature again. There was in several instances a temporary loss of moment

of 4 per cent or 5 per cent, but this loss seemed to disappear entirely after the magnet had been allowed to stand for about 24 hours. The numbers in the second column of Table I show the difference between the moments of a certain cylindrical magnet, 0·5^{cm} in diameter and 15^{cm} long, at 17° and at the temperature indicated by the corresponding numbers in the first column. These differences are expressed in terms of the original moment at the room temperature of 17°.

TABLE I.

Temperature.	Loss of moment in terms of the original moment at 17°.
17°	0·0000
43	0·0043
64	0·0091
81	0·0131
100	0·0180
81	0·0134
60	0·0094
19·5	0·0012

Effects of a similar nature might have been looked for if observations had been taken without allowing ample time for the magnet to attain a uniform temperature at each stage, but it is certain that no sensible error from this source enters into the results here given.

Many seasoned magnets show no measurable time lag in attaining their original moments after they have been heated to 100° C., and none show any such lag if they have been heated to only about 20° above the room temperature and then cooled, or if they have been heated to 100° shortly before the experiment has begun. In other words, a second heating immediately after the first does not add to the temporary loss of moment brought about by the first heating. When a seasoned magnet is exposed to constantly higher and higher temperatures it attains at each stage, in a fraction of a minute, a state which it would keep sensibly unchanged if exposed for hours to that temperature.

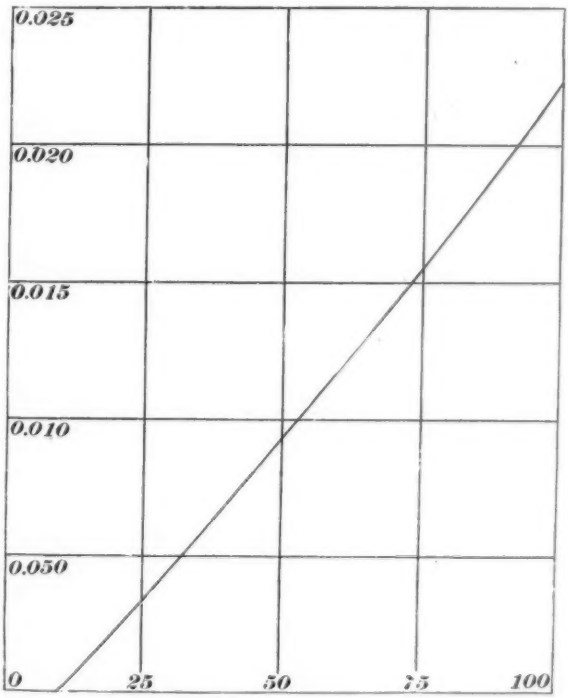
With very few exceptions all the magnets tested had distinctly greater temperature coefficients at higher temperatures than at lower temperatures, so that if the losses of moment in terms of the moment of the original low temperature be used as ordinates and the temperatures as abscissas, the curve is concave upwards. In the case of magnets made of a single specimen of tool steel 1·11^{cm} in diameter, the concavity was extremely small and in a solitary instance there was a distinct convexity, but other magnets made of the same bar as this

abnormal one gave curves like those of the hundreds of other magnets experimented on.

Many curves were obtained with rising temperatures, but as has been said these sometimes differ slightly from those made with falling temperatures, unless the magnet has been recently boiled when no such difference appears. In some instances the curve is almost straight from room temperatures up to 40° C., and is again nearly straight between 80° and 100°, so that most of the curvature falls between 40° and 80°.

As fair examples I give (in Tables II, III and IV) the results of observations made for me with great care on three magnets. If the temperatures are used as abscissas and the fractional loss of magnetic moment as ordinates, Tables II and III yield curves which are concave upwards, while the curve obtained from Table IV is nearly straight. These curves are shown in figures 1, 2, and 3.

1.



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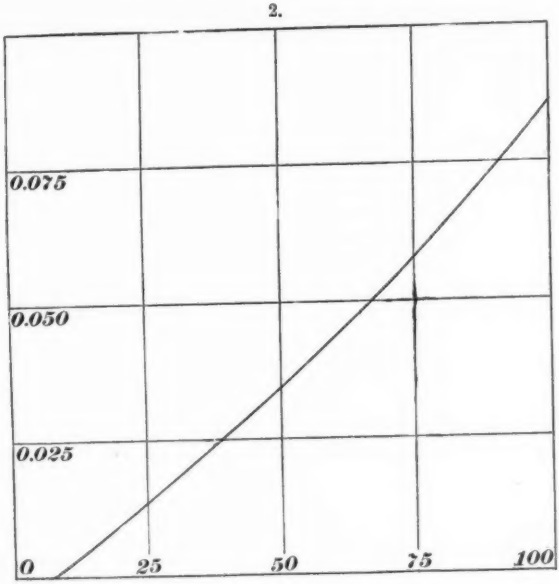

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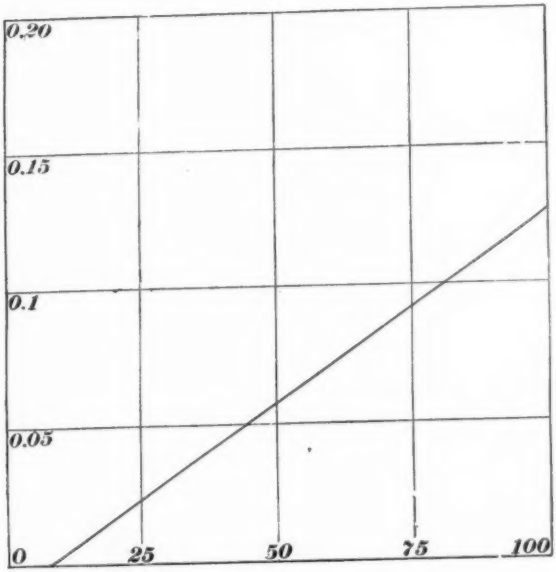


Table II.

Results of 25 observations on a seasoned magnet 20^{cm} long made of Crescent Drill Rod 0·81^{cm} in diameter.

Temperature.	Loss of magnetic moment in terms of the moment at 10° C.
10	0·0000
20	0·0022
30	0·0045
40	0·0068
50	0·0092
60	0·0117
70	0·0142
80	0·0167
90	0·0194
100	0 0223

Table III.

Results of 33 observations on a seasoned magnet 8^{cm} long made of Crescent Drill Rod 0·94^{cm} in diameter. (Last decimal place in doubt.)

Temperature.	Loss of magnetic moment in terms of the moment at 7·6° C.
7·6	0·0000
12·0	0·0033
20·0	0·0097
30·0	0·0178
40·0	0·0262
50·0	0·0347
60·0	0·0435
70·0	0·0532
80·0	0·0639
90·0	0·0751
100·0	0·0872

Table IV.

Results of 42 observations on a seasoned magnet 6^{cm} long made of Crescent Drill Rod 1·11^{cm} in diameter. (Last decimal place in doubt.)

Temperature.	Loss of magnetic moment in terms of the moment at 8·1° C.
8·1	0·0000
12·0	0·0052
20·0	0·0160
30·0	0·0298
40·0	0·0434
50·0	0·0570
60·0	0·0707
70·0	0·0845
80·0	0·0982
90·0	0·1122
100·0	0·1265

After I had determined the characteristic form of the temperature curves of such bar magnets as made up my collection, it remained to find out how the temperature coefficients at ordinary temperatures and the average loss of magnetic moment when the magnets were heated from room temperature to 100° C. vary with the dimensions of the magnets. Of course the temperature coefficients of magnets made of different kinds of steel may differ widely in absolute value, but my experiments seem to show that for most common kinds of fine steel their values change relatively in much the same way with the dimensions of the magnets. I had a number of brands of steel made by several makers, but the results given here were mostly obtained with Crescent Drill Rod and Jessops Square Tool Steel. Crescent Drill Rod is usually magnetically indistinguishable from Jessops Round Tool Steel. Stubs Drill Rod makes somewhat weaker magnets, but the difference is slight. Some brands of special steel, intended for telephone magnets and the like, make stronger magnets than the polished drill rod, but are not so advantageous as the latter for such purposes as deflector magnets, the moments of inertia of which must be computed. The measurements were made in a similar manner to those mentioned in the preceding pages, but the magnet was fixed in a holder in a non-magnetic tube, through which steam, tap water, or water at any convenient tempera-

ture might be sent in a constant flow. The magnetic field about the magnetometer needle was in some cases weakened to make the apparatus more sensitive.

In measuring many seasoned magnets of a given size I have often found, as has been already said, one or two magnetically much weaker than the average, and these generally had very large temperature coefficients. I have rejected all such as being imperfectly hardened, and have assumed that magnets having high moments and low temperature coefficients are representative. Results obtained with such magnets give smooth curves.

TABLE V.

Crescent Polished Drill Rod.
Diameter, 0·64cm.
Weight per cm. of length, 2·4 grams.

Length in centimeters.	Approximate magnetic moment, per gram of the seasoned magnet at 15° C., expressed in c. g. s. units.	Mean loss per degree of the magnetic moment when the magnet is heated from about 15° C. to 1·0° C., expressed in terms of the moment at the lower temperature.	Temperature coefficient of the seasoned magnet at 15° C.
3	5·0	0·00114	0·00057
4	7·0	0·00091	0·00049
5	9·0	0·00073	0·00044
6	11·0	0·00060	0·00039
8	15·0	0·00043	0·00030
10	19·0	0·00035	0·00026
12	23·0	0·00030	0·00023
15	31·0	0·00026	0·00021
20	43·0	0·00024	0·00020

TABLE VI.

Crescent Polished Drill Rod.
Diameter, 0·81cm.
Weight per cm. of length, 3·9 grams.

Length in centimeters.	Approximate magnetic moment, per gram of the seasoned magnet at 15° C., expressed in c. g. s. units.	Mean loss per degree of the magnetic moment when the magnet is heated from about 15° C. to 1·0° C., expressed in terms of the moment at the lower temperature.	Temperature coefficient of the seasoned magnet at 15° C.
6	13·0	0·00087	0·00077
8	17·0	0·00080	0·00070
10	20·0	0·00073	0·00064
12	24·0	0·00066	0·00058
15	29·5	0·00057	0·00050
20	41·0	0·00040	0·00037

Table VII.

Crescent Polished Drill Rod.
Diameter, 0·95cm.
Weight per cm. of length, 5·5 grams.

Length in centimeters.	Approximate magnetic moment, per gram of the seasoned magnet at 15° C., expressed in c. g. s. units.	Mean loss per degree of the magnetic moment, when the magnet is heated from about 15° C. to 100° C., expressed in terms of the moment at the lower temperature.	Temperature coefficient of the seasoned magnet at 15° C.
6	10·0	0·00086	0·00078
8	14·0	0·00078	0·00070
10	17·0	0·00071	0·00063
12	20·5	0·00063	0·00056
15	26·0	0·00055	0·00049
20	36·5	0·00040	0·00036

Table VIII.

Crescent Polished Drill Rod.
Diameter, 1·11cm.
Weight per cm. of length, 7·6 grams.

Length in centimeter.	Approximate magnetic moment, per gram of the seasoned magnet at 15° C., expressed in c. g. s. units.	Mean loss per degree of the magnetic moment when the magnet is heated from about 15° C. to 100° C., expressed in terms of the moment at the lower temperature.	Temperature coefficient of the seasoned magnet at 15° C.
4	5·5	0·00110	0·00109
6	8·5	0·00088	0·00087
8	10·0	0·00070	0·00070
10	12·0	0·00062	0·00062
15	19·5	0·00052	0·00051
20	30·5	0·00048	0·00047

Table IX.

Twice hardened Crescent and
Jessops Drill Rod.
Diameter, 0·95cm.
Wt. per cm. of length, 5·5 grams.

Length in centimeters.	Approximate magnetic moment, per gram of the seasoned magnet at 15° C., expressed in c. g. s. units.	Mean loss per degree of the magnetic moment when the magnet is heated from about 15° C. to 100° C., expressed in terms of the moment at the lower temperature,
4	5·0	0·00158
6	7·5	0·00133
8	10·0	0·00115
10	13·0	0·00106
12	16·0	0·00094
15	20·5	0·00088
18	26·0	0·00082

Table X.

Jessops Square Tool Steel.
Dimensions of cross section 0·81 × 0·81cm.
Wt. per cm. of length, 5·3 grams.

Length in centimeters.	Approximate magnetic moment, per gram of the seasoned magnet at 15° C., expressed in c. g. s. units.	Mean loss per degree of the magnetic moment when the magnet is heated from about 15° C. to 100° C., expressed in terms of the moment at the lower temperature.	Temperature coefficient of the seasoned magnet at 15° C.
4	4·5	0·00163	0·00139
5	6·0	0·00145	0·00116
6	8·0	0·00125	0·00102
8	11·5	0·00103	0·00087
10	16·0	0·00094	0·00078
14	24·5	0·00080	0·00065
20	38·0	0·00065	0·00051

TABLE XI.

Jessops Flat Tool Steel.
Dimensions of cross section, $1{\cdot}6^{cm} \times 0{\cdot}32^{cm}$.
Wt. per cm. of length, 3·9 grams.

Length in centimeters.	Approximate magnetic moment, per gram of the seasoned magnet at 15° C., expressed in c. g. s. units.	Mean loss per degree of magnetic moment when the magnet is heated from about 15° C. to 100° C., expressed in terms of the moment at the lower temperature.
6	11·0	0·00089
8	15·0	0·00071
10	18·5	0·00058
15	27·5	0·00034
20	36·5	0·00028

TABLE XII.

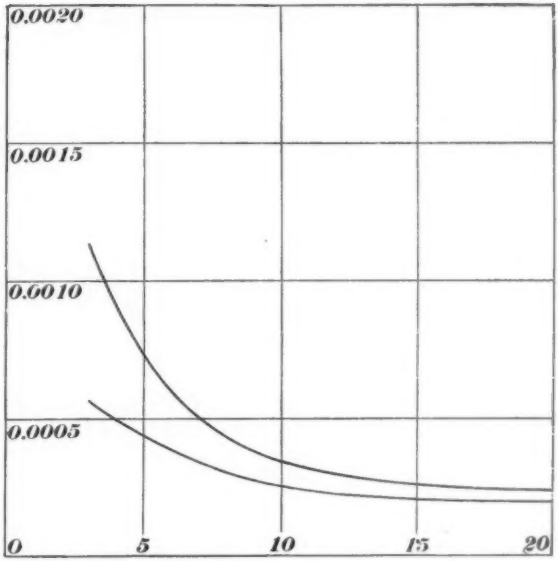
Tubular magnets of Crescent Polished Drill Rod.

Length in centimeters.	Outside diameter in centimeters.	Inside diameter in centimeters.	Mean loss per degree of the magnetic moment when the magnet is heated from about 15° C. to 100° C., expressed in terms of the moment at the lower temperature.
6	0·95	0·70	0·00087
7	0·95	0·70	0·00075
7·5	1·28	0·94	0·00063
10·	1·28	0·94	0·00061

Tables V to XII show how the temperature coefficients of magnets made of different specimens of steel and their losses of magnetic moment between room temperatures and 100° C. varied with their lengths. It is evident that in the case of magnets made of a given kind of steel, the temperature coefficients are functions of both the diameters of the magnets and of the ratios of their lengths to their diameters. Very long slender magnets have in general relatively small temperature coefficients, but it does not seem possible to reduce indefinitely the coefficient of a magnet made of a stout rod of tool steel by increasing the length. Figures 4, 5, 6, 7, and 8, in which the lengths of the magnets are used as abscissas, show graphically the results given in Tables V, VI, VII, VIII, and X, and recall Cancani's experiments upon magnets made of fine steel wire.

The Jefferson Physical Laboratory,
Cambridge, December, 1897.

4.



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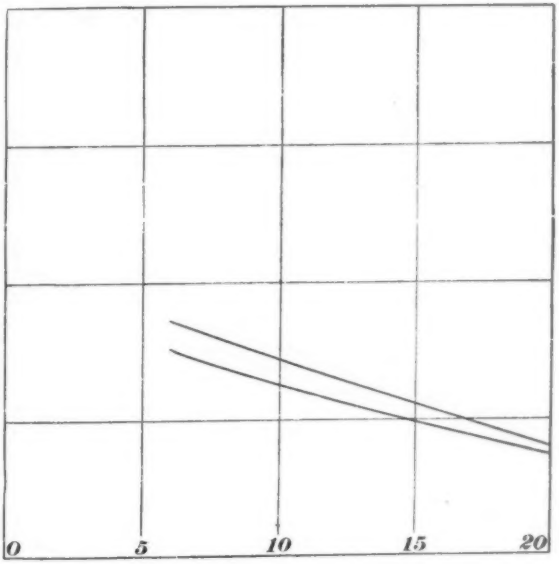

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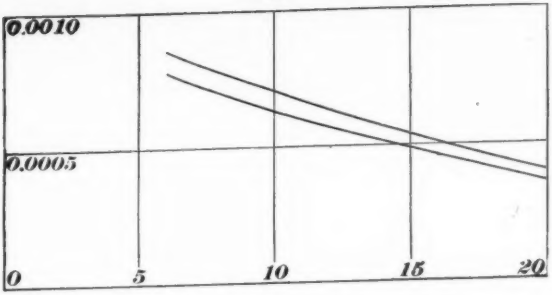
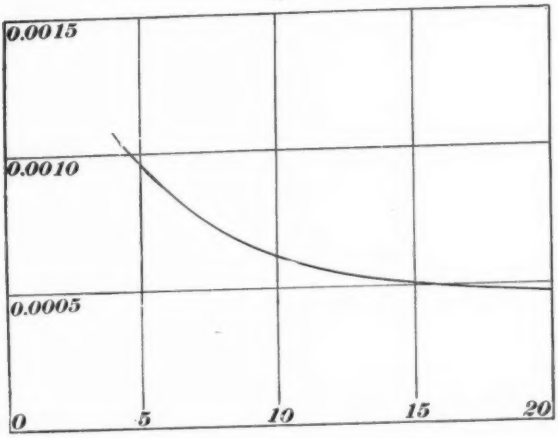
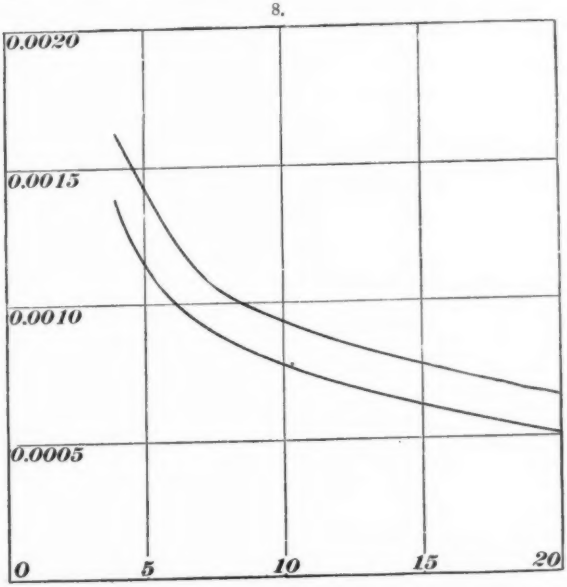

0.0010
0.0005
0
5
10
15
20

7.


0.0015
0.0010
0.0005
0
5
10
15
20

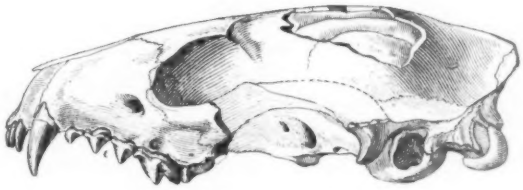
8.


0.0020
0.0015
0.0010
0.0005
0
5
10
15
20

ART. XXXII.—*On the Skull of Amphictis;* by E. S. RIGGS.

THE genus Amphictis has so far been made to include three species: *A. antiquus** from Saint-Gerard-le-Puy, and *A. leptorhynchus** and *A. ambiguus*† from the Quercy phosphorites. All of these forms are based upon mandibular characters, and so far only a single upper tooth has been described.‡ The genus is characterized by Schlosser as follows:§ "Diese Gattung zeichnet sich vor Allem aus durch den einfachen Bau der *Pr* und durch die Länge des unteren zweiwurzligen M_2. Die Vorderpartie dieses Zahnes besteht aus einem Aussen- und einem Innenzacken, der Vorderzacken ist schon sehr undeutlich geworden. Der Talon ist sowohl am M_1 als auch am M_2 als Schneide entwickelt, wenigstens der Hauptsache nach."

An almost complete skull (No. 11455) in the Princeton collection from the Phosphorites probably belongs to this genus, although it is decidedly smaller than the specimens hitherto referred to it, and the means of positively determining it as such are not at hand.



Lateral view of the skull ×1.

The upper dentition is, I3, C1 P4, M2. The incisors have conical crowns slightly compressed antero-posteriorly. The third is much larger than the first and second. The canines are somewhat recurved and are oval in cross section. The first premolar is still functional, but has lost the anterior root. The second is larger, two-rooted, concave on both borders and retains a slight basal cingulum posteriorly. The third premolar is only a little larger than the second but has a basal cingulum on the anterior as well as on the posterior side. The sectorial is similar to that of *Putorius*, but has a stronger internal tubercle and a less prominent anterior cingulum. There is no fissure between the median cusp and the heel as in the civets.

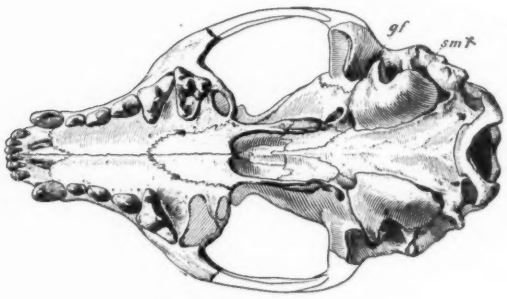
* Pomel, Catalogue méthodique. p 63

† Gervais, Zoölogie et Paleontologie, gen. ii, p. 51.

‡ Schlosser, Die Lemuren, Chiropteren, etc., des europäischen Tertiars, p. 121.

§ Idem, p. 118.

The first molar bears three small but well-marked tubercles. Of these the inner one is the largest; it is flanked by a prominent internal cingulum which may be regarded as an incipient fourth cusp. The outer tubercles are shifted mesially, leaving a broad external surface which is elevated to form a marked prominence at the acute antero-external angle. In outline the anterior border is convex, the posterior concave. The second molar has been lost from both sides of the specimen, but the alveolas show that it was reduced to a single-rooted tooth.



Base of the skull ×1.

The characters of the base of the skull show affinities with both the mustelines and the Viveridæ. The alisphenoid canal is present as in the viverines and the older fossil cats. The otic bullæ are well inflated and there is no inferior lip to the auditory meatus, as is true of the viverines; but the tympanic walls are much thickened and inclose but a single cavity, into which the meatus externus enters at the middle much as in the mustelines. The paroccipital processes are free from the bullæ and are directed backward, downward and outward as in the early Carnivora and Creodonts. The mastoid processes are blunt and inconspicuous, but lie close to the meatus and form part of its posterior wall as in certain mustelines. The posterior nares open on a line with the last molars; the pterygoids are grooved infra-laterally.

The posterior lacerate foramen opens at the posterior border of the bulla near the stylo-mastoid as in *Bassaris*,* and the carotid foramen lies just in front of it as in that form. The foramen ovale and the posterior opening of the alisphenoid canal lead into a common fossa, as in the civets and the early cats. The post-glenoid foramen opens at the extremity of the anterior rim of the auditory meatus and is partially concealed

* Flower, Proceedings of the Zoölogical Society of London, 1869, p. 10.

by it. The posterior palatine foramina appear just back of the maxillo-palatine suture.

The occiput is nearly perpendicular. The lambeloidal ridges are prominent only at the inion. There is no sagittal crest; the *linea semicircularis* are only slightly marked and do not unite until they reach the occiput, enclosing a narrow sagittal area. The cranium is expanded, showing a large and well-convoluted brain.

The frontal region is concave along the median suture; the nasals are narrow and slender as in the civets. The post-orbital processes are only slight, but back of them there is a marked notch-like constriction.

The measurements are as follows:

	M.
Length of skull from incisors to condyles	·074
Breadth across mastoid processes	·031
Height of occiput above condyles	·021
Glenoid cavity to incisors	·054
Breadth across post-orbital processes	·019
Occiput to incisors	·076
Incisors to last molar	·085
Length of molar dentition	·026
Breadth of incisor dentition	·008
Breadth across first molars	·027
Length of base of sectorial	·008
Breadth " "	·0055
Length of base of first molar	·006
Breadth " "	·0085
Greatest breadth of nasals anteriorly	·007
Breadth of nasals at middle	·004

It will be seen that Amphictis, though by no means a primitive form, has many characters in common with both Mustelidæ and the Viveridæ. The general proportions of the skull are musteline. The structure of the inner ear, and of the paroccipital and mastoid processes are essentially characteristic of that group, as are also the presence of the glenoid, and the distinct condylar foramina. But on the other hand the short and expanded auditory meatus, the inter-sagittal space, the character of the molars, and the presence of the alisphenoid canal ally it to the viverines. Thus the genus forms a connecting link between the two families and furnishes further evidence in support of Schlosser's theory that they are of common origin.*

* Die Lemuren, Chiropteren, etc., de europäischen Tertiars, p. 107.

Princeton University.

Art. XXXIII.—*On the Condition of Oxidation of Manganese precipitated by the Chlorate Process;* by F. A. Gooch and Martha Austin.

[Contribution from the Kent Chemical Laboratory of Yale University—LXVIII.]

Hannay,* who was the first to propose the precipitation of manganese from its solution in nitric acid by the use of potassium chlorate, states that precipitation is complete, but that the oxide produced is not of constant composition. While, therefore, precipitation by this method serves an excellent purpose in separating manganese from other substances, it was Hannay's opinion that reliance cannot be placed upon the determination of the oxygen value of the oxide to estimate the manganese. Beilstein and Jawein,† who proposed the same method, subsequently, regarded the precipitate as the oxide MnO_2. Hannay's reaction was developed, independently, by Hampe‡ and Ford§ into the method which is now known as the "chlorate process" for the estimation of manganese. The discussion of the exact condition of the precipitated oxide was very active ten years ago, and occasional echoes of it are heard at the present day; and yet, in all this discussion we find no account of an adequate test of the process upon an exact amount of a salt of manganese known to be pure. The discussion for the most part has centered about the degree of oxidation of the precipitate, but there is obviously another condition to be taken into account, viz: the possibility of the mechanical inclusion of the comparatively insoluble chlorate in the precipitated oxide. As to the existence of the latter source of error we have had in the course of our work very strong affirmative evidence, the apparent condition of oxidation of the precipitate being sometimes so high as to be otherwise inexplicable. This difficulty does not occur, however, when a more soluble chlorate is chosen to do the work of oxidation, and we have found quite as convenient and much safer the substitution of sodium chlorate for the comparatively insoluble potassium chlorate. Besides, the rapidity with which the sodium chlorate is decomposed makes its use an advantage.

With regard to the completeness of the precipitation our experience has shown that with due precaution the method is practically perfect. Thus, after boiling manganous nitrate (free from chlorides and sulphates) with strong nitric acid (85^{cm^3}) and sodium chlorate (5 grms.) for five minutes, adding, subsequently, 15^{cm^3} of the nitric acid and a few crystals more of

* Jour. Chem. Soc., vol. xxxiii, 269.
† Ber. d. d. Chem Gesell., xii, 1528.
‡ Chem. Central-Blatt, 1885, 714. § Trans. Inst. Am. Min. Engineers, ix, 347.

the sodium chlorate, and discontinuing the heating as soon as the liquid again boils, the insolubility of the manganese is so great that no more than insignificant traces may be recovered from the filtrate after cooling, filtering upon asbestos and washing with water. The test for manganese in the filtrate and washings was made after evaporation and solution of the residue in distilled water by treating the hot solution with bromine and ammonia. In the first division of the table below are results obtained by treating the manganese precipitated from the filtrate with potassium iodide and sulphuric acid, the iodine set free being determined by sodium thiosulphate. In the second series the precipitated manganese dioxide was reduced by a known amount of decinormal arsenious acid and the amount remaining unoxidized was estimated by titration with iodine in the presence of acid potassium carbonate.

TABLE I.

$MnSO_4$ taken. grm.	Mn found by KI treatment in filtrate. grm.	Mn found by As_2O_3 treatment in filtrate. grm.
0·3361	none	----
0·3361	none	----
0·3361	0·00006	----
0·3361	0·00005	----
0·3361	0·00002	----
0·3361	0·00008	----
0·3361	none	----
0·4128	----	0·00003
0·4128	----	0·00003
0·4128	----	Trace
0·4128	----	Trace

It will be seen that in no case did the manganese which escaped precipitation—that which corresponded to the iodine freed or the arsenious acid oxidized—exceed 0·0001 grm. Plainly this modified method of handling the chlorate process may be trusted to precipitate the manganese with gratifying rapidity and approximation to completeness. Our experience has shown plainly that prolonged boiling results in a considerable loss of manganese (from 0·0010—0·0030 grm.). This we think is due to the solvent effect of the lower oxides of nitrogen naturally produced (as is always the case in boiling nitric acid) after the chlorine dioxide has been thoroughly expelled. An excess of the chlorate at the end of the boiling seems to be essential and a slight yellow color in the solution, due to chlorine dioxide, is a favorable indication rather than the reverse. We find it best to filter the undiluted nitric acid, under pressure,

upon asbestos on a perforated cone with a filtering surface of about 40$^{sq\ cm}$. The dilution of the nitric acid before filtration tends to produce some solubility of the manganese, and the loss then introduced, though trifling if the filtration is rapid, may be considerable if the process of filtration is prolonged, as is the case in the method approved by the "Verein der deutschen Eisenhütteleute."*

Our experiments upon the chlorate process have been made with manganous chloride prepared as detailed in a former paper, viz: by boiling manganous chloride with manganous carbonate, precipitating the filtered solution with ammonium sulphide, dissolving the washed manganous sulphide in dilute hydrochloric acid, precipitating the solution thus obtained with sodium carbonate (after boiling out hydrogen sulphide), dissolving the greater part of the manganous carbonate (thoroughly washed by repeatedly boiling it in successive portions of water) in the least amount of hydrochloric acid, and boiling the solution thus obtained with the remainder of the pure carbonate and filtering. The standard of the solution thus prepared, neutral and probably very pure, was fixed by evaporating definite portions with sulphuric acid and weighing the residue as the normal sulphate in accordance with the procedure outlined in a former paper.†

Any method, by means of which the oxidizing power of the higher oxygen compounds of manganese is discoverable, may, obviously, be employed to determine the condition of the manganese precipitated in this chlorate process. Convenient processes for the determination of the available oxygen in the higher oxides of manganese are the iodometric methods of Bunsen and Pickering. Bunsen's method is applicable to any of the higher oxygen compounds of manganese—though somewhat inconvenient because it involves the distillation of the chlorine liberated by the action of strong hydrochloric acid upon the substance and its collection in potassium iodide, the iodine thus set free being estimated by standard thiosulphate. According to Pickering's‡ method the higher oxide is treated immediately with potassium iodide and hydrochloric acid and the iodine liberated is estimated by sodium thiosulphate. Plainly, the latter method is limited to the treatment of the less refractory or more finely comminuted oxides, and it fails in the presence of ferric salts and all other substances capable of liberating iodine from the acidified iodide.

Still another general iodometric method for determining the oxygen value of the higher oxides of manganese is suggested

* Von Reis, Zs. f. angewandte Chem., 1891, 376.
† This Journal. IV, v. 209.
‡ Jour. Chem Soc., xxxvii, 128.

by Deshayes's titration of permanganic acid in nitric acid by means of standard arsenious acid.* Our experience in following out this idea shows that the precipitated oxides of manganese, as well as the soluble permanganate, may be easily reduced with the aid of gentle heating by arsenious acid in the presence of sulphuric acid, and that the determination of the excess of arsenious acid by titration with iodine after neutralization of the free sulphuric acid by an alkaline carbonate gives exact data for estimating the oxidizing power of the manganese compound. We found, however, that if the iodine is allowed to come into contact with the manganous carbonate thrown down by the alkaline carbonate, as is inevitable for at least short intervals during the titration of the arsenious acid in presence of the floating carbonate, the danger arises of more or less reoxidation of the manganous carbonate by the iodine and the consequent introduction of error. Fortunately the difficulty may be obviated by adding to the solution while still acid enough tartaric acid, or alkaline tartrate, to prevent the precipitation of the manganese in the subsequent neutralization by the bicarbonate.

Confining our attention to the last two simpler iodometric methods—the reduction of the higher oxide by an acidified iodide on the one hand and by arsenious acid on the other—we made, first, some experiments to determine the accuracy with which manganese may be thus estimated. We used for the manganese compound of known oxidizing power a solution of potassium permanganate filtered carefully through asbestos and standardized against ammonium oxalate which had been found to be the exact equivalent of a specially prepared lead oxalate. For each experiment a definite portion of this solution was drawn from a burette and treated with a solution of pure manganous sulphate until the color of the permanganate had vanished, thus precipitating a hydrous oxide approximating quite closely probably to the condition of oxidation of the dioxide, but containing at all events, whatever its actual composition might be, the exact amount of available oxygen originally in the permanganate. In the experiments of the following table this precipitate was treated with a solution of potassium iodide (6 grm.) and tartaric acid (10 grm.), by which the freshly prepared hydrate is dissolved quite as well as by the iodide and hydrochloric acid of Pickering's original method and with less risk of evolution of iodine outside the main reaction. From the iodine found by titration with this sulphate we have calculated the weight of manganese dioxide which would liberate it; and a comparison of this value with the amount of the dioxide theoretically precipitated by the interaction of the

* Bull. Soc. Chim., xxix, 541.

known permanganate and the sulphate, upon the assumption that two molecules of the former throw down five molecules of the hydrated dioxide, should disclose the error of the analytical process when applied to the estimation of manganese dioxide. In all probability the assumption that it is the dioxide that is precipitated, and which afterwards acts upon the iodide, is not quite true under the conditions, since the precipitation takes place in presence of an excess of a manganous salt; but for our purpose it does not matter, since we are in effect simply dealing with the oxidizing power of a known amount of permanganate.

TABLE II.

Mn theoretically precipitated by $KMnO_4$ as MnO_2.	Mn in MnO_2 corresponding to iodine found.	Error of the analytical process (applied to MnO_2) in terms of Mn.
grm.	grm.	grm.
0·1351	0·1347	0·0004—
0·1351	0·1347	0·0004—
0·1351	0·1350	0·0001—
0·1351	0·1353	0·0002+
0·1351	0·1358	0·0007+
0·1351	0·1353	0·0002+

Thus, it is obvious that the mean error of the results is practically inconsiderable, varying between extremes of −0·0004 grm. and +0·0007 on 0·1351 grm. of manganese dioxide.

In the experiments of Table III the precipitated oxide was treated with an excess of a standard arsenious acid solution and 5^{cm^3} of sulphuric acid of half strength, and the whole was heated until the manganese dioxide was dissolved. To this liquid was added tartaric acid (10 grm.) to prevent the precipitation of the manganese and the oxidation by iodine in the subsequent titration, the acid was neutralized by acid potassium carbonate, and the arsenic still remaining in the arsenious condition titrated by standard iodine.

TABLE III.

Mn precipitated by action of $KMnO_4$ on $MnSO_4$ as MnO_2.	Mn in MnO_2 corresponding to As_2O_3 oxidized.	Error of the process in terms of Mn.
grm	grm.	grm.
0·1392	0·1396	0·0004—
0·1109	0·1117	0·0008—
0·1112	0·1117	0·0005—
0·1109	0·1117	0·0008—
0·1109	0·1117	0·0008—
0·1117	0·1125	0·0008—

It is clear that either of these methods of reduction, the action of an acidified iodide or that of arsenious acid, is capable of yielding fairly accurate indications when we have to deal with a pure salt of manganese. When, however, the manganese is associated with a considerable amount of iron, as is frequently the case, it becomes a matter of necessity to separate the manganese before attempting its estimation. For this purpose the "chlorate process" is by far the simplest of those generally used, and though it has been the subject of much discussion, it is at present the method of separation most widely used by the practical chemists, whether the final estimation of the manganese is made gravimetrically, as in Ford's process, or volumetrically, as in the methods of Volhard, Williams, or Pattinson.

Definite portions of the solution of pure manganous chloride were drawn from a burette into an Erlenmeyer flask of 300^{cc} capacity, evaporated to dryness, precipitated by the "chlorate process" with the modifications given in detail above. The oxide, after careful washing, was returned with the asbestos to the flask and treated by one or other of the methods to be described. It was either treated with potassium iodide (5 grms.) and sulphuric acid (10^{cc}) of half strength, the iodine set free being estimated by thiosulphate; or, it was heated with an excess of standard arsenious acid and 10^{cc} of sulphuric acid of half strength, and after cooling, adding 5 grm. of the Rochelle salt and neutralizing with acid potassium carbonate, the arsenious acid remaining unoxidized was estimated with standard iodine. In Table IV are given the results obtained from this work.

TABLE IV.

Mn taken in the form of manganous chloride. grm.	Mn found upon the hypothesis that MnO_2 is precipitated. grm.	Error. grm.	Mn found in the filtrate after evaporation and treatment with bromine and ammonia. grm.
By reduction with potassium iodide.			
0·1225	0·1183	0·0042—	0·00006
0·1225	0·1177	0·0048—	Trace
0·1225	0·1180	0·0045—	0·00008
0·1225	0·1169	0·0056—	Trace
By reduction with arsenious acid.			
0·1222	0·1189	0·0033—	Not determined.
0·1222	0·1191	0·0031—	" "
0·1222	0·1199	0·0023—	" "
0·1222	0·1200	0·0022—	" "
0·1222	0·1186	0·0036—	none
0·1222	0·1187	0·0035—	0·0001
0·1222	0·1189	0·0033—	0·0002
0·1222	0·1194	0·0028—	Trace
0·1222	0·1205	0·0017—	0·0001

The results show plainly that, while the manganese is so completely precipitated in the chlorate process of oxidation when properly conducted that only insignificant traces may escape, the condition of oxidation cannot be taken to be that of the dioxide. The average error thus put upon the determination of the manganese known to be present is more than two per cent. It follows, as a matter of course, that the indications of any process which rests upon the assumption that the oxygen value of the manganese compound precipitated in the chlorate process corresponds to that of the dioxide must of necessity be erroneous. If, therefore, the chlorate method is to be employed for the separation of the manganese, it is obvious that precautions must be taken to secure a definite condition of oxidation of the manganese before processes which depend upon the oxygen value of the higher oxide may be applied for the estimation of that element. The process which in our hands seems to give the oxide in definite condition is based upon the observations of Wright and Menke* that a dilute solution of potassium permanganate acting in excess, at 80° C., in the presence of zinc sulphate, and in thorough mixture upon manganous sulphate, yields an oxide which, though combined with alkali, holds the oxygen exactly in the proportion corresponding to the dioxide. Three-fifths of the manganese in such a precipitate represents the amount of that element originally present in the manganous salt. In the following table are given the results of experiments in which manganese was determined iodometrically after the interpolation of the permanganate treatment.

In these experiments a solution of manganous chloride of known strength was drawn from a burette, evaporated to dryness in a small beaker, heated with nitric acid until there was no evidence of the presence of nitrogen oxides. Strong nitric acid was poured in until the volume was 85$^{cm^3}$, sodium chlorate (5 grm.) was added carefully, the liquid was boiled five minutes, more nitric acid (15$^{cm^3}$) and a few crystals of the chlorate were introduced, and the solution brought to boiling temperature again. After cooling, the liquid was filtered on asbestos and washed with water, and the oxide upon the asbestos and walls of the beaker was dissolved in 2$^{cm^3}$ of hydrochloric acid. After diluting a little the solution was evaporated with 5$^{cm^3}$ of strong sulphuric acid until no more hydrochloric acid remained. The solution of manganous sulphate (not exceeding 0.5 grm. of the salt), very nearly neutralized by potassium carbonate, was mixed with a solution of zinc sulphate (2 grm.) and a freshly and carefully filtered dilute solution of potassium permanganate (1·5 grm. of the salt), the liquid, amounting now to about

* Jour. Chem. Soc., xxxvii, 36.

500$^{cm^3}$, was heated to 80° C., and acid potassium carbonate added, in quantity a little more than enough to neutralize the remnant of the acid present. The precipitate was collected upon asbestos, and after careful washing was returned to the flask in which the precipitation had been made. The oxygen value of the oxide was determined by one or other of the methods described. In the one case the flask was fitted with a paraffined stopper having two bores, one holding a Will and Varrentrap absorption apparatus (in which a solution of potassium iodide dissolved any escaping iodine), the other a small separating funnel. Sulphuric acid and potassium iodide in solution were run in through the funnel, the iodine set free was titrated with thiosulphate—the amount of manganese being reckoned from the iodine set free. The results of this work follow in the first part of Table V. In the second case the dioxide obtained in the manner described above was reduced by warming gently with a decinormal solution of arsenious acid. After cooling, and neutralizing with acid potassium carbonate in the presence of Rochelle salt, the excess of the arsenious acid was estimated with iodine in the presence of starch. The estimation by this method gave the results recorded in the second part of Table V.

TABLE V.

Mn taken in the form of chloride. grm.	Mn found upon the hypothesis that MnO_2 is the oxide finally obtained. grm.	Error. grm.
	By reduction with potassium iodide.	
0·0643	0·0637	0·0006—
0·0643	0·0642	0·0001—
0·0643	0·0642	0·0001—
0·0651	0·0651	0·0000
0·1125	0·1121	0·0004—
0·1125	0·1121	0·0004—
0·1125	0·1120	0·0005—
0·1214	0·1206	0·0008—
0·1214	0·1207	0·0007—
0·1214	0·1223	0·0009+
0·1214	0·1214	0·0000
	By reduction with arsenious oxide.	
0·1213	0·1212	0·0001—
0·1213	0·1201	0·0012—
0·1213	0·1203	0·0010—
0·1213	0·1208	0·0005—

These results show plainly, that if the precautions to which attention has been directed are taken, viz: dilution of the solution and heating to 80° C., presence of zinc sulphate, and (most essential of all) the almost complete neutralization of free acid before the addition of the potassium permanganate, the manganese dioxide precipitated by the chlorate process from pure manganous nitrate may subsequently, after reduction, be brought by the permanganate treatment so nearly to the full degree of oxidation represented by the symbol MnO_2, that the amount of manganese originally treated may be calculated with a very fair degree of accuracy from the oxygen value of three-fifths of the oxide found. We do not recommend this procedure as a rapid analytical method; our purpose is accomplished when the fact is brought plainly to view that the oxide precipitated by the chlorate process is not the dioxide, but that it may be made such by subsequent treatment.

Art. XXXIV.—*San Angelo Meteorite;* by H. L. Preston, Rochester, N. Y.

[Read before the Rochester Academy of Science, March 8th, 1898.]

The San Angelo siderite is oblong in shape and was, previous to cutting, 51^{cm} long by 29^{cm} wide and 14^{cm} thick. Its weight was 194 pounds or 88 kilos. A considerable portion of this siderite was obtained by Prof. H. A. Ward, Chief of Ward's Natural Science establishment, through the courtesy of Prof. Geo. P. Garrison of the University of Texas, Austin, Texas, and he is indebted to Mr. James Abe March of San Angelo, Texas, for the facts in reference to its locality, and the manner in which it was found.

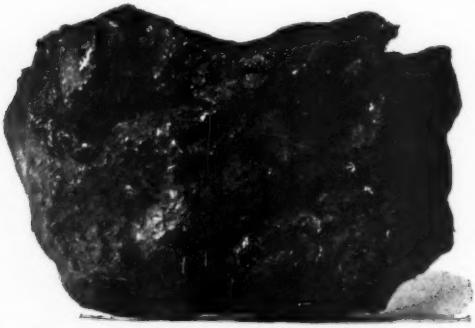
San Angelo meteorite; about $\frac{1}{6}$ natural size.

It was discovered by Mr. John Johnson on the prairie seven miles south of San Angelo, Tom Green County, Texas, about July 1st, 1897. The prairie on which the meteorite was found is called "Lipan Flats," a body of land entirely devoid of vegetation, without even mesquite trees. The meteorite was partially buried in the soil, and Mr. Johnson discovered it while riding horseback in search of cattle, and states that unless one rode over it, it would not have been seen, as the color of the soil and the meteorite were nearly the same.

The exterior surface of the mass is of a dark reddish brown color, considerably spotted with large yellow patches. None of the original crust is perceptible. The surface is very much oxidized and some places can be seen where scales a quarter of an inch or more in thickness have flaked off, thus intimating that the mass had lain for many years in its original position

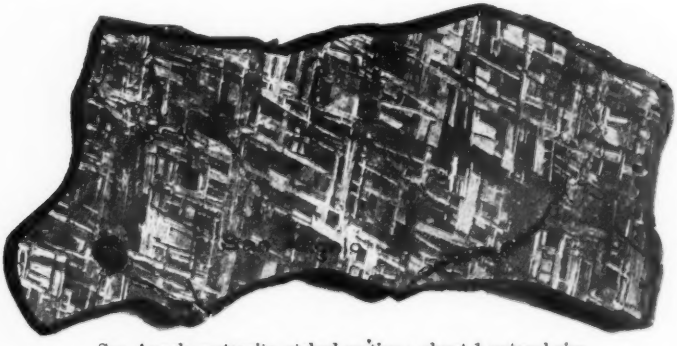
where discovered. The surface of the iron is marked on all sides by large and characteristic pittings, some of them as much as 12^{cm} in diameter.

At one end of the meteorite several ounces had been forced from the main mass, which has left a rough, jagged surface five by six inches.



San Angelo meteorite showing octahedral structure; $\frac{1}{4}$ natural size.

This is of unusual interest, as the octahedral structure of the iron is beautifully shown by numerous octahedral faces, the largest of which is one and a quarter inch in diameter and is very sharp and clear. So also are many of the smaller octahedral faces shown over this surface where the separation of the mass was made.



San Angelo meteorite, etched section; about $\frac{1}{4}$ natural size.

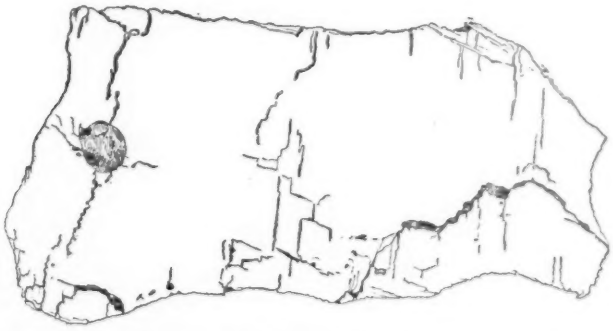
A portion of this part taken off has been forged in a blacksmith shop: this piece when polished and etched has the same

general appearance as have all forged meteoric irons we have seen.

On slicing the mass we find the troilite nodules very scarce, the largest and only prominent one we have come across being 26^{mm} in its greatest diameter and continuing of this size only through three thin slices. The Widmanstätten figures are brought out sharp and distinct on the etched surfaces, and are much more regular both in form and size, than in any other iron with which I am familiar. The rhombic figures are from an inch to an inch and a half in diameter, and vary but little throughout the mass. The so-called Laphamite lines are prominently present, extending across the large patches of plessite.

There are two exceedingly interesting veins which appear on either end of most of the slices, that are filled with a black, lustrous graphitic-looking mineral; the longest of these veins following the curve is 11^{cm} and varies from 1 to 4^{mm} in width; the other is 6^{cm} long with a like variation of from 1 to 4^{mm} in width.

Another distinguishing feature of this iron are the numerous small fissures or cracks, usually extending from the exterior surface inwards, and following in a zigzag course along the edges of the kamacite plates, and in some instances the rhombic form of



San Angelo meteorite sketch showing fissures; about $\frac{1}{2}$ natural size.

the Widmanstätten figures as seen on the cut showing etched surface, is strongly outlined by these fissures as seen in sketch. These show clearly that with a little more heat the expansion of these cracks or fissures, would have caused masses to separate from the iron, which would tend to cause the large pittings, as suggested by me in an article in the January number of this year, of this Journal. In one case, as seen in left-hand edge of cut,

if a separation had taken place along these fissures, it would have created a cavity or pitting four inches in diameter and one inch or more in depth, while numerous smaller pittings could have been created in the same way as suggested by following the outline of the fissures on cut.

The following is an analysis of the San Angelo meteorite by Mariner & Hoskins of Chicago, Ills.

Fe	91·958
Ni	7·860
Co	*trace*
Cu	0·040
P	0·099
S	0·032
Mn	*trace?*
Si	0·011
C	*trace*
	100 000
Specific gravity	7·7

ART. XXXV.—*The Pre-Glacial Decay of Rocks in Eastern Canada;** by ROBERT CHALMERS, of the Geological Survey of Canada.

THE pre-glacial decay of rocks in glaciated countries is a subject which has not hitherto received much attention from geologists. In North America the chief investigations regarding subærial rock decay have been made in regions to the south of the glaciated zone, and but little has been attempted in those portions once occupied by Pleistocene glaciers. The prominence given to the action of these glaciers may have been one of the causes of this neglect or inattention to the products of rock-decomposition. The bowlder-clay and certain gravels and sands overlying it being of considerable thickness, and their origin having apparently been found readily explicable from the action of these glaciers, the sedentary beds beneath, which occur usually in thin and detached sheets in glaciated regions, have thus, to a large extent, been overlooked. That they form a very important member of the superficial deposits, nevertheless, in the glaciated areas of Eastern Canada at least, and one from which the bowlder-clay and all the other overlying stratified deposits have been mainly derived, no geologist will now attempt to deny.

In the regions of North America to the south of the glaciated belt the beds formed from rock decomposition have been studied, together with the stratified deposits resulting from their modification, by a number of leading geologists. Chamberlin and Salisbury, McGee, Hilgard and others have investigated their character and relation to the later superficial deposits; while near the limits of the glaciated area, T. Sterry Hunt† and Pumpelly‡ have shown the depths to which this process of decay penetrated and the manner in which the different kinds of rocks have been attacked by it. Russell has treated the question in its wider bearings and given detailed notes and descriptions regarding the chemical and mechanical agencies by which these changes in the rocks are effected; but his work also appertains to non-glaciated portions only of the United States.§ Prof. Kerr has shown how frost affects the decayed rock materials on slopes and declivities, an action which must be of more potent effect in Canada than in the Southern Appalachians.‖

* Paper read in Section C (Geology) British Association for the Advancement of Science, Toronto, August, 1897.

† This Journal, vol xxvi, 1883, pp. 190–213, etc.

‡ Ibid., 3d series, vol. xvii, 1879, pp. 133–144.

§ Bulletin U. S. Geological Survey, vol. viii, 1888–89.

‖ This Journal, 3d series, vol. xxi, 1881, pp. 345–358.

An ample field for the study of rock-decay and of the different agencies by which it is effected exists in Canada, in which few workers have yet been found. In the eastern portion, previous to 1882, when the writer began investigations in the surface geology of the Maritime provinces, only two geologists were known to have observed phenomena of this kind. Sir J. W. Dawson had noted decomposed slates at Les Eboulements on the north side of the St. Lawrence below Quebec;* and Dr. T. Sterry Hunt observed the products of rock-decay on the south side of Mount Royal, at Montreal, and also at Rigaud Mountain in Vaudreuil.† In these and other places, e. g., Ste. Anne de Beaupre, Charlesbourg near Quebec, Portneuf, Lachute, etc., the materials in question lie at the southern base of ridges or hills and have escaped the eroding action of the Pleistocene ice. Since the date above mentioned the writer has collected a considerable body of facts relating to this subject in the eastern portion of Canada to which reference has been made in reports on the surface geology of New Brunswick, Nova Scotia and Prince Edward Island in the volumes since published by the Geological Survey of Canada. In the present paper an attempt is made to collect together the results of the scattered observations of these years and draw the attention of geologists to these ancient and very interesting products of rock-decay which seem to be the only remnants now in existence here representing the long ages which elapsed between the Carboniferous, or rather the Triassic, and the Pleistocene.

The question of rock-decay in the geological ages which preceded the Tertiary, however, is not here considered. No remnants of such, as distinct from those of later ages, have been recognized in the region under discussion. But it is possible they do exist, though indistinguishable from those of Tertiary age. Fossil evidence is, so far, entirely wanting in the pre-glacial decayed rock materials of Eastern Canada.

Definition of Terms.

Preliminary to a discussion of the pre-glacial decayed rock materials, it is, perhaps, desirable to explain and define certain terms employed in this paper regarding them. The materials in question have been found to be principally of two classes—*sedentary* and *modified*. The term *sedentary* is used to designate all those portions of the rock surface of the region which have decomposed *in situ* whether to greater or less depths, and which, although now in the form of loose gravel, sand, etc.

* Notes on the Post-Pliocene Geology of Canada, Can. Naturalist, 1872.
† This Journal, vol. xxvi, 1883, pp. 208–209.

have not been removed from their original situation. These have sometimes been called residuary or indigenous, or simply rotten rock *in situ*.

The *modified* pre-glacial beds consist really of the sedentary material removed from their original position, and worn and changed by the agency of rivers, streams, and, perhaps, to some extent by that of the atmosphere before they were deposited in stratified beds. They are best developed in protected valleys, although oftentimes greatly eroded and in places almost wholly swept away by glacial denudation and river action. In some valleys, owing to the heavy filling of bowlder-clay thrown down upon them during the glacial period, or to the dislocation of portions of the valleys from local differential movements, they have been partially preserved and form thick stratified deposits.

Physiographic Features of the Region.

Topographically the region embraced in these observations exhibits highly diversified features and its geological formations include a great variety of rocks of different ages and character. It has also been the theater of a remarkable system of mountain-building action, and has undergone great and repeated oscillations of level. The subærial erosion and base-levelling to which it has, from time to time, been subjected, have doubtless largely obliterated the original features, except within a few limited areas,—the only plane surfaces of any extent now existing, properly attributable to these causes, being the St. Lawrence valley and the Carboniferous area of New Brunswick. The northeast Appalachian Mountain system constitutes the principal topographical feature, extending throughout the entire length of the region and terminating at Gaspé. This system has subsidiary and parallel ranges or spurs with intervening valleys. As a rule these valleys are floored with the latest rocks, and thick deposits of Pleistocene age usually occupy them. Although the existing mountain ranges and valleys were originally due to orogenic movements, the minor topographical features are largely the result of the processes of disintegration referred to slowly and unceasingly in progress. The slates and sandstones seem to have been more deeply decomposed than the crystalline rocks. In the valleys and especially beneath the bowlder-clay, the decomposed products under consideration are found in the thickest beds, although usually occurring also upon the slopes and ridges. Thus while glacial erosion and other forms of denudation have been active and long-continued, these sedentary and other pre-glacial stratified beds have been preserved in sheets of greater or less extent and thickness in every part of the country.

Distribution of the Decayed Rock Materials.

Pre-glacial beds of decomposed rock, sedentary and stratified, have been observed by the writer in Quebec, New Brunswick, Nova Scotia, Prince Edward Island and the Magdalen Islands. In some localities the sedentary or indigenous materials occur apparently in extensive sheets; in others they are detached and local. For the most part they were met with in fragmentary masses, however, having evidently been much denuded before the bowlder-clay was laid down upon them. In a few places in Quebec and in Prince Edward Island, also in the Magdalen Islands, these decomposition products have been partially assorted, and now form thick stratified deposits in river valleys. It is in the bottom of these that gold is found in the Chaudière valley, and other places in the "Eastern Townships" of Quebec. Similar assorted and re-assorted fluviatile deposits, though of greatly reduced thickness, occur in certain parts of Nova Scotia, having been observed along the northern slope and base of the Cobequid Mountains, also in several parts of Prince Edward Island. The Magdalen Islands are non-glaciated, and hence the decayed rock materials there are nearly in the same condition yet as they were in other parts of Eastern Canada previous to the glacial period, forming thick beds which have been slightly assorted by marine action during the Pleistocene submergence. It is in the river valleys of southeastern Quebec as referred to above, that the decomposed materials underwent the greatest transportation and assortment, as will appear by the sections of these beds given on the following pages.

Wherever these decomposition products occur in sedentary beds, though mantled by bowlder-clay, the rock surface beneath is without striation from ice. And from the occurrence of these in so many localities it is evident that a considerable extent of rock surface in Eastern Canada has not been scored nor abraded during the glacial period, the ice apparently having slid over the beds which covered it with a sluggish motion, impinging only against the more prominent parts of the solid rock beneath and striating these.

In the province of Quebec these beds appear, as stated above, to have been least denuded in the hilly broken country lying between the St. Lawrence River and the International boundary, the ridges serving as barriers to protect them in many places from denudation by the Pleistocene ice. The comparatively light erosion of the first glaciation of the Appalachian system, and the mantling of these beds by the bowlder-clay produced by it, preserved them also, to some extent, from the more powerful erosion of the Laurentide ice which followed.

Hence the occurrence of these sedentary beds, locally, in greater thickness here than in most other parts of the region under review. It is, however, chiefly in the form of deposits which have been assorted and re-assorted from the original sedentary material that they are found in the ancient river bottoms. Sections of these have been exposed in the banks of the Chaudière, Du Loup, Ditton and other rivers from which a knowledge of their character and relation to the other deposits, as well as to the solid rocks beneath, has been obtained.

At St. George, on the east bank of the Chaudière River, a tunnel was run in 800 or 900 feet in search of the pre-glacial channel of Slate Creek—a small tributary—passing through bowlder-clay and other beds beneath to the rock surface. The beds inferior to the bowlder-clay, which is here about 60 feet in thickness, were found to be in descending order,—(1) stratified sand and clay (locally called by the miners quicksands and pipe-clay); (2) coarse stratified gravel with pebbles and a few bowlders; (3) a local deposit of coarse slaty materials, apparently decomposed quartzose slate, thrown down probably as talus at the foot of a slope or bank, though at present forming a compact bed; (4) fine-grained, yellow sand with ochreous streaks. The stratification of this is obscure, but it is evidently parallel to that of the next bed beneath wherever it is seen. (5) The last graduates into rotten rock *in situ*, the stratification of which is quite distinct, dipping southeastward at a high angle; (6) slates and sandstones, decaying, fissile, and non-glaciated.

This section it will be seen, exhibits in descending order three different kinds of deposits beneath the bowlder-clay, viz: (1) transported and water-worn material, (2) talus, and (3) sedentary beds passing into the solid rocks below.

Another section of the pre-glacial deposits is shown in an old hydraulic pit in the valley of Rivière du Loup, about a quarter of a mile from its junction with the Chaudière. The succession here is as follows, in descending order: (1) bowlder-clay, with an intercalated, stratified band,—thickness of the whole 75 feet; (2) tough, dark gray, stratified clay, 1 to 3 feet; (3) gray, ochreous sand, stratified, (quicksands of the gold miners,) 12 to 14 feet; (4) compact unstratified clay, (pipe-clay of the miners,) 6 feet; (5) gray stratified gravel, with numerous pebbles and a few water-worn bowlders, 5 feet; (6) hard, yellow, oxidized gravel, stratified, with an abundance of worn bowlders from two feet in diameter downwards, containing alluvial gold in the bottom, 28 to 30 feet. None of the materials are glaciated and all are of local origin. The foot of the bank was covered with tailings, but near by the

sedentary materials and non-glaciated rock surfaces were observed.

Beneath the bowlder-clay in this section we have, therefore, a thickness of about 45 feet of assorted, water-worn, stratified deposits, apparently all derived from sedentary, decayed rock material. The lower portions are coarse and oxidized throughout, the upper mostly finer and showing less oxidation, having evidently been laid down in deeper and quieter waters. These appear to rest upon denuded beds of rotten rock and non-glaciated rock surfaces. No fossil remains have yet been detected in them; but they are probably of Tertiary age. It is not unlikely that they are the equivalents of certain beds discovered many years ago at the western base of the Green Mountains at Brandon, Vermont. These were said to form a deposit lying beneath the bowlder-clay and resting upon the solid rocks, which showed gravel and sand with kaolin or porcelain clay, and lignite or fossil wood, as well as several other oxidized materials. Fossil fruits were also discovered there, from which Mr. Lesquereux was led to refer the beds to the Miocene.*

In the valley of the Little Ditton River, oxidized pre-glacial materials, carrying gold, were also noted. Like those of Rivière Du Loup, they are chiefly of alluvial origin, but the portions resting immediately upon the rough, broken, jagged surfaces of the non-glaciated slates were sedentary.

Beyond the limits of the "Eastern Townships" so called, these materials were observed in a great number of places in southeastern Quebec not only in valleys, but on the hillsides and at the base of declivities, where they have been, in some way, protected from denudation. They were noted on Orleans Island, in Montmagny county, also near Rivière du Loup, Intercolonial railway, and at Little Metis. Indeed, many parts of the Notre Dame Range, on the St. Lawrence slope, exhibit more or less pre-glacial rock debris *in situ* with talus at the base, the glaciation here having been produced chiefly by northward moving ice which failed to remove it.

In the Gaspé peninsula similar decomposition products occur in some localities, and certain non-glaciated marginal areas were seen along the coast. The most remarkable example of this kind met with is on the point of land terminating in Cape Gaspé. This point has never been glaciated, and is covered with decayed rock material and devoid of bowlder-clay. We have here a remnant of the land surface in the same condition as it was in the Tertiary period.

Local sheets of these decayed rock materials were first noted

* Geology of Canada, 1863, p. 929.

in the maritime provinces of New Brunswick, Nova Scotia and Prince Edward Island upon areas occupied by Carboniferous rocks, and have subsequently been observed in almost every part both of the higher and lower grounds. In the numerous localities where they were seen the superposition of the bowlder-clay was a constant feature, except in the Magdalen Islands, where the products of glacier action seemed to be absent. In the great Carboniferous plain the general character and condition of these beds are closely similar throughout and are such as to indicate that, in pre-Pleistocene time, a thick continuous sheet existed. They are much thicker and of greater bulk in Prince Edward Island, however, than on the mainland, in many places exceeding the bowlder-clay beds in volume. In the central part of the island along the railway line, where they seem to have suffered less denudation than on the coast, beds of sedentary material, five, ten and even twenty feet in thickness were observed. In many places they are capped only by stratified or partially stratified gravel, sand, and clay of variable thickness, due to fluviatile, marine, or perhaps ordinary atmospheric action, though usually bowlder-clay overlies them throughout the island. On the mainland of New Brunswick and Nova Scotia, especially near the coast, the decomposed materials were seldom seen *in situ* of greater thickness than about five feet, and often not exceeding a foot or two. A section at one of the numerous localities in which these products occur in the Carboniferous area of New Brunswick, seen along the highway between Chatham and Richibucto near the Black River bridge, is as follows: (1) Gravel and sand, unstratified, containing flat, angular fragments of rock apparently *in situ* imbedded therein, thickness, eighteen inches; (2) rotten rock, with loose pieces of the underlying sandstones also in place, but with a little gravel and sand in the interstices, four to five feet; (3) gray sandstone showing still less decomposition, and evidently passing into the solid rocks (millstone grit) beneath, which here lie nearly horizontal.

Wherever the unabraded or non-glaciated rock surface beneath the decayed rock is exposed, it usually presents a mammillated appearance, showing that the corroding action has penetrated more deeply in some spots than in others. No foreign bowlders or other drift materials occur in these beds, though they are not uncommon in the overlying bowlder-clay and upon the surface.

In southern New Brunswick and in some parts of northwestern Nova Scotia the character of the decomposed beds is different from that of those met with upon the Carboniferous areas, being dependent upon, and of course closely related to, the underlying rocks there. On the pre-Cambrian the materials

are coarser and often contain pebbles and bowlders of considerable size, the finer matter having evidently been carried away by post-glacial denudation. In the hilly districts bordering the Bay of Fundy, talus was observed at the base of the slopes in a few places. On the Cambrian and Cambro-Silurian this debris is finer and where slates prevail the materials are in loose, fissile beds, i. e. they occur in the form of thin laminæ or scaly fragments of all sizes lying in the same position as the original strata. Materials of this kind were observed in the southern counties of New Brunswick, also on the south side of the St. Lawrence near Quebec. The decayed rock upon these and the older formations is less gravelly and sandy than upon the Carboniferous sandstone areas, as might naturally be supposed.

In many parts of the Maritime provinces these decomposition products were observed to have been only partially or slightly acted upon by the Pleistocene ice. In this condition they seemed to contain the same angular pebbles or gravel as the rotten rock *in situ* beneath, but were shifted greater or less distances from their original position by glacier-ice, and the interstices filled with a bluish or gray clay, or sandy clay, as the case might be, which baked hard on exposure. Beds of this kind usually graduate upwards into true bowlder-clay.

The occurrence of such extensive sheets of decomposed sedentary rock in the region under consideration, much denuded as they seem to be, points to the former existence of a universal mantle of this material overspreading the country everywhere in Tertiary and preceding ages, probably from the first appearance of dry land. It was, however, partly modified by the same agencies as are in operation around us at the present day, namely by rivers, lakes, rain, snow, etc., and in the valleys, especially, was changed into deposits of stratified clay, sand and gravel. During the glacial period this decayed rock furnished the principal portion of the material constituting the bowlder-clay, and also that of the overlying, modified, post-glacial beds.

Agencies which produced Decomposition of the Rocks.

The indigenous materials under discussion appear to be the result mainly of two different agencies—mechanical and chemical. Although it is not the purpose of the writer to enter into details regarding these in the present paper, it may be stated, that under the climatic conditions of this country, the most important seem to be (1) the precipitation, and (2) the carbonic acid of the atmosphere and of decaying vegetable matter, the latter usually resulting in what is called oxidation. The changes of temperature which have such a wide range in these latitudes must also have exerted a direct influence in pro-

ducing expansion and contraction of the rocks, thus causing numerous superficial cracks, crevices and joints which open them to the disintegrating agents referred to. Exfoliation, which is often seen in granite districts, and sometimes on diorite bosses, is chiefly due to this expansion and contraction. Although at first glance decomposition would seem not to have been as deep in this country as to the south of the glaciated zone, yet such an inference may not be correct, owing principally to the fact that denudation has been so much greater; and the existing remnants of these pre-glacial beds do not by any means show the amount of rock-decay which took place. The removal of so much of the decayed materials by atmospheric and glacial action must have exposed some portions of the rock surfaces at least to a renewed attack of the disintegrating processes time after time—a condition of things which would not occur so generally in regions upon which ice never gathered. It is true that the mantle of snow which envelopes the earth's surface here for five or six months every year and the freezing of the superficial beds during the same period have a conservative effect, and tend to check and practically arrest decomposition for a certain time; but rock-decay, nevertheless, may have been more effective and rapid at other seasons than in those parts of the earth where the decayed materials lie and accumulate as residuary beds to a great thickness. Thus while the process referred to does not exhibit the accumulated beds here that are found in southern latitudes, it does not necessarily follow that the depth of such action may not have been as great. The fact just stated has to be borne in mind, namely, that the decayed materials have undergone great denudation, thus giving the disintegrating forces renewed power at intervals to act directly upon the rocks.

The principal oxidation and decay of the rocks would seem to be from chemical agencies, whether on the surface as the rotten rock was denuded, or deep-seated beneath a load of sedentary material, or along joints, cracks, etc. These processes have been in incessant operation since the region became dry land. At present the great mantle of bowlder-clay acts as a preserver of the rocks from the decaying processes in many districts, though even under this impervious capping the agents of decomposition, doubtless, to some extent, carry on their work.

It thus appears that if the climate and the seasons of Eastern Canada in past ages were at all similar to those prevailing at the present day, the conditions of rock-decay would necessarily be somewhat unlike those of tropical and non-glaciated regions, though probably the results may not have been very far different. The general character of the beds might possibly be nearly

the same in both regions, but for the reasons stated they may never have been as deep in the glaciated zone. The facts would seem to point to the conclusion, however, that rock-decay has been in progress in this country for long ages, probably as long as in southern climates, although somewhat irregular and intermittent in its operations.

From the extent and depth of the sedentary and assorted beds found beneath the bowlder-clay it may be inferred that the Pleistocene glaciers were not as heavy, or of such erosive power, as many geologists have supposed. This has been the case especially in the flat districts of the Maritime provinces occupied with Carboniferous rocks. In these districts the ice has been of a less vigorous and sweeping character than in the more elevated parts of the country, and was apparently sluggish in movement, passing over the loose deposits and rock surfaces without eroding them deeply. Only from certain low ridges, or from the brows of hills exposed to the full force of the grinding ice masses, have the decomposition products been wholly removed and the surfaces of the solid rocks beneath scored and laid bare.

The general aspect of the dry land in Eastern Canada before the advent of the glacial period must have been closely similar to that of the country to the south of the glaciated area. The greater denudation it has suffered since from subærial and glacial agencies and the filling up of the valleys, partially or wholly with the bowlder-clay, thus levelling and reducing the inequalities of the surface, have largely modified, in some places entirely changed, the appearance. But amid all the vicissitudes of climate and oscillations of level which the region underwent, and the denudation to which the surface has been subjected, these products of rock-decay, representing the subærial action of long ages, have thus been preserved in remnants and detached sheets, the recognition of which unfolds another episode in the geological history of Eastern Canada hitherto overlooked, and adds new interest to the study of its superficial deposits.

Geological Survey Office, Ottawa, May, 1897.

Art. XXXVI.—*A New Form of Make and Break;* by Charles T. Knipp.

A make and break to operate a sounder so as to tick seconds is indispensable in a well-equipped physical laboratory. The method of allowing a tip of platinum wire, fastened to the lower end of the second's pendulum, brush through a drop of mercury on an amalgamed brass or copper support, is vexing in the extreme and not in the least reliable. It requires constant attention, as the mercury is readily oxidized by the making and breaking of the current.

The following device is easily made and can be readily attached to any second's pendulum. The general arrangement is at once seen by aid of the figures.

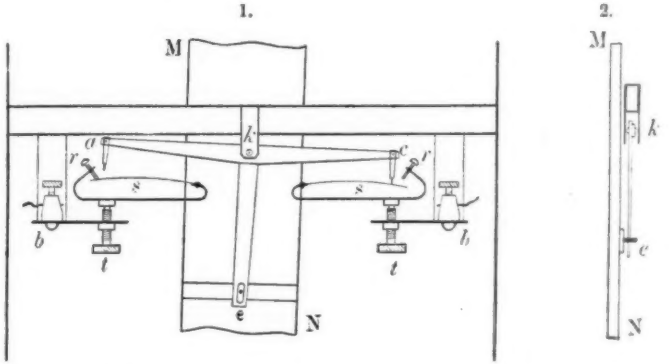


Fig. 1. The T, *a c e* is pivoted at *k*; *s, s* are delicate springs made of sheet steel. Adjustments are made by means of the thumb screws *t, t* and the set screws *r, r*. The current is connected through the binding posts *b, b*. The pendulum MN carries a stud which engages the lower end of the T, *a c e*.

Fig. 2. Shows a side elevation and manner of pivoting at *k*.

The T-shaped frame is made of thin sheet brass. It is pivoted at the center. At the lower end of the stem of the T is a slot which engages a stud on the pendulum. Fastened to the ends of the arms are short arms which project downward. At the lower end of each small arm is soldered a platinum tip. Clamped at one end of a brass frame, supported by a thumb screw, is a delicate spring of sheet steel. The spring is held in the desired position by a set-screw at the other end of the frame, as shown in the left hand side of fig. 1. The adjustment should be such that when the pendulum is in its lowest position the platinum tips just touch the springs. The adjust-

ment is readily effected by means of the thumb and the set-screws. Two binding posts are conveniently placed to which the circuit from the battery and sounder is connected. Obviously the circuit is closed only when the pendulum passes through its lowest point—when the platinum tips are in contact with the two springs. Fig. 1 shows the pendulum at the extreme end of its path. The right-hand spring is depressed while the left-hand platinum tip is a considerable distance above its spring. A small piece of platinum foil is soldered to the spring just below the platinum tips to insure good electrical contact. The friction is very slight. The pendulum, as a consequence, will have a smaller amplitude, causing the clock to run some faster. The friction at the points of contact of the platinum tips can be greatly reduced by shortening the arms of the T, thus making the springs and arms of equal length and approximately radii of the same circle. Fig. 2 is a side view showing the stud on the pendulum, the pivot, and support.

The writer made this device and placed it in position March, '97. After being once adjusted it gave no trouble. Wires were run to the various laboratory rooms. The device is always ready and responds promptly when the sounder is attached.

Physical Laboratory, Indiana University,
Bloomington, Ind.

ART. XXXVII.—*Datolite from Guanajuato;* by OLIVER C. FARRINGTON.

WHILE examining, about two years ago, the mineral collection of Sr. Ponciano Aguilar, the well-known mining engineer of Guanajuato, Mexico, my attention was attracted to some small transparent crystals accompanying a specimen of calcite from the San Carlos mine of Guanajuato.

As I could not at the time identify the crystals, Señor Aguilar kindly presented me with the specimen that I might give them further study. A subsequent determination of the blowpipe characters showed the mineral to be datolite, a species which has not so far as I know been previously reported from this locality. Examination of the crystal form showed the habit and development of the crystals to be unique and apparently peculiar to the locality. They were accordingly made the subject of the following study.

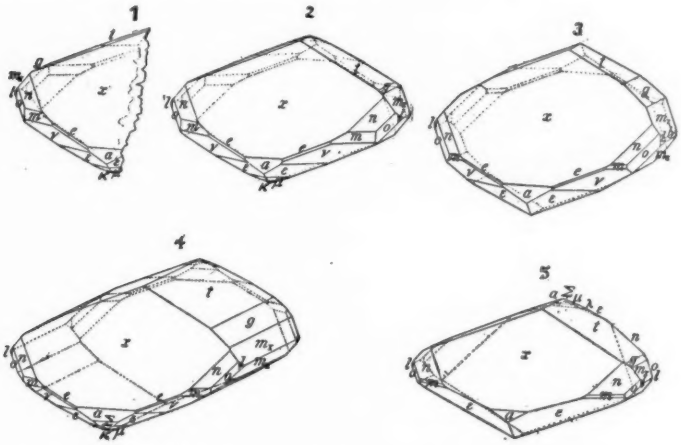
The calcite crystals with which the datolite is associated have the form of $-\frac{5}{4}$ rhombohedrons which are coated with drusy calcite. Small quartz crystals about 5^{mm} in length and made up of the usual prism terminated by the + and − rhombohedron also accompany them. Regarding the nature of the occurrence of the specimen, Señor Aguilar was unable to give any further information than that it was from the mine already mentioned. The rocks of the region are, however, well known to be altered andesites.

The datolite crystals are transparent, colorless, of vitreous luster and small size, the largest being not over 4^{mm} in length by 1^{mm} in thickness. Upon them a total number of 17 forms was identified, as follows, the symbols being in accordance with those chosen by Dana:

$a(100,\ \bar{i}\text{-}\bar{i})$	$x(102,\ -\frac{1}{2}\text{-}\bar{i})$	$\kappa(\bar{1}15,\ \frac{1}{5})$
$b(010,\ i\text{-}i)$	$\Sigma(\bar{3}02,\ (\frac{3}{2}\text{-}i)$	$\mu(\bar{1}14,\ \frac{1}{4})$
$e(320,\ i\text{-}\frac{3}{2})$	$t(013,\ \frac{1}{3}\text{-}i)$	$\lambda(\bar{1}13,\ \frac{1}{3})$
$m(110,\ I)$	$g(012,\ \frac{1}{2}\text{-}i)$	$\epsilon(\bar{1}12,\ \frac{1}{2})$
$o(120,\ i\text{-}2)$	$m_{\frac{1}{2}}(011,\ 1\text{-}i)$	$\nu(\bar{1}11,\ 1)$
$l(130,\ i\text{-}3)$	$n(111,\ -1)$	

The faces are fairly sharp and bright but in the zones of prisms and hemi-pyramids merge into one another so that it is difficult to distinguish them. The crystals all have about the same number of faces, but differ in the faces developed. The prisms have about the same development on all the crystals. Thus *e*, 320, is scarcely more than a line; *m*, 110, and *o*, 120,

appear as well-defined faces, while *l*, 130, is always a minute triangular face at the edge of *e*. The negative hemi-pyramid *n*, 111, is always well-defined, and the positive hemi-pyramids, *ν*, $\bar{1}11$, and *ϵ*, $\bar{1}12$, are usually prominent. The succeeding faces of this zone round off in a manner which has been noted on datolite from other localities. The clinodomes can usually be distinguished by being duller in luster than the other faces and by their showing minute striations diagonal to their edges. The habit of the crystals is determined by the predominance of the orthodome *x*, 102, the crystals being tabular with respect to this face, and of the clinodomes *t*, *g* and m_x. To these faces the prisms and pyramids are quite subordinate and, as mentioned later, may become very minute. The habit produced by predominance of the faces mentioned may perhaps best be described as an arrow-point habit. It is illustrated by fig. 1. As here indicated,



only half the crystal is present in nature and that the left half, the point of attachment being near the symmetry plane. This development is very constant and by being familiar with it one can recognize the prominent faces at a glance.

Crystals approaching these in habit, in that they are tabular with respect to *x*, have been described by E. S. Dana from Bergen Hill, N. J.,* and by Franzenau from the Swiss Alps in Tyrol.† The Guanajuato crystals differ, however, from those described by Dana in that they only rarely have a rhombo-

* This Journal, III, vol. iv, p. 17, and fig. 14, pl. 1.
† Handbuch der Mineralogie, C. Hintze, p. 173.

hedral aspect and from those of both authors in the predominance of the clinodome *t*, 013. Through the kindness of Prof. Dana, I have had an opportunity to examine some undescribed crystals from Bergen Hill which resemble the Guanajuato forms more closely. In these the clinodomes *t* and *g* are still lacking, their place being supplied by the pyramid G, but the habit, mode of attachment and relative development of the faces is such as to make the crystals in other respects very similar to the Guanajuato forms. They differ from the Bergen Hill type already referred to, chiefly in the subordinacy of ϵ, $\bar{1}12$. They may therefore be considered as a simple modification of this type.

In order to illustrate the different types observed on the Guanajuato datolites, four crystals, which are represented in the accompanying figures, were chosen. Crystal No. 1 is shown in completed form in fig. 2, fig. 1 showing the left half of the same crystal. This crystal illustrates what is perhaps the commonest type, the crystal being thin by reason of the shortness of the clinodiagonal axis, and rather acutely terminated on account of the predominance of the clinodome *t*. From the series of positive hemi-pyramids it will be noticed by the figure that the pyramid λ, $\bar{1}13$, is wanting and this was usually true, the face being found on only one crystal.

Measurements in the zones of prisms, pyramids and domes showed in all cases close approximation of measured to calculated values. A zone well brought out on this crystal is that of *x* over *n* to *x*. Measured and calculated angular values in this zone compared as follows:

	Measured.	Calculated.
$102 \wedge 1\bar{1}1$	34° 20′	34° 21′
$1\bar{1}1 \wedge 1\bar{2}0$	29 42	29 50
$1\bar{2}0 \wedge 0\bar{1}\bar{1}$	52 1	51 53
$0\bar{1}\bar{1} \wedge \bar{1}0\bar{2}$	63 57	63 56

Fig. 3 illustrates the second crystal chosen. Here the clinodomes have a more nearly equal development than in the previous forms and the crystal has, therefore, a more blunt termination. The clinopinacoid is present, but only two of the series of positive hemi-pyramids occur, these being, as may be noted on the figure, ν, $\bar{1}\bar{1}1$, and ϵ, $\bar{1}12$. Measurement of the zone *x* over *n* on this crystal gave the following results:

	Measured.	Calculated.
$102 \wedge 1\bar{1}1$	34° 21′	34° 21′
$1\bar{1}1 \wedge 1\bar{2}0$	29 51	29 50
$1\bar{2}0 \wedge 0\bar{1}\bar{1}$	51 54	51 53
$0\bar{1}\bar{1} \wedge \bar{1}0\bar{2}$	63 49	63 56

Another interesting zone well developed on this crystal is that of x over t to x. In this zone the measured and calculated angles compared as follows:

	Measured.	Calculated.
$102 \wedge 3\bar{2}0$	49° 20′	49° 21′
$3\bar{2}0 \wedge 1\bar{1}\bar{1}$	24 46	24 46
$1\bar{1}\bar{1} \wedge 0\bar{1}\bar{3}$	56 45	56 40
$0\bar{1}\bar{3} \wedge \bar{1}0\bar{2}$	49 15	49 13

In crystal No. 3, shown in fig. 4, the forms are much extended in the direction of the clinodiagonal axis, making a thicker crystal and one which displays more than the others the rhombohedral appearance noted by Dana. Here the pyramids and prisms appear only as a slight truncation of the edge formed by the meeting of the orthodome and the clinodomes, and might therefore easily be overlooked. The crystal shows no new faces except the positive hemi-orthodome Σ, $\bar{3}02$, which here appears for the first time.

The crystal shown in fig. 5 is peculiar for displaying a merohedrism worthy of note. The series of fundamental positive hemi-pyramids is here represented in the upper rear octants by ϵ, $\bar{1}12$, λ, $\bar{1}13$, (this face not being wanting from the series as in the other crystals) and κ, $\bar{1}14$. These faces are all small, and only slightly truncate the edge formed by the junction of the orthodome x and clinodome t. In the lower front octants, however, λ and κ are wanting and only ϵ appears, so greatly enlarged that it is equal to t in size. The crystal shows, therefore, inclined-faced hemihedrism with respect to λ and κ, and were ϵ not present could properly be termed hemihedral. As this face is present, however, the absence of the other faces should more properly perhaps be regarded as accidental and the occurrence be considered due to merohedrism.

It may be worthy of note that in measuring the smaller faces I found direct sunlight reflected by a movable mirror a more satisfactory source of light than any artificial light. Signals could be obtained from faces by this means which gave none whatever with artificial light. With a darkening attachment on the goniometer work in a dark room with its heat and bad ventilation is thus avoided and in most cases good readings could be made from sunlight even without the darkening attachment.

Field Columbian Museum, Chicago, Feb. 1, 1898.

ART. XXXIX.—*On Clinohedrite, a new mineral from Franklin, N. J.;* by S. L. PENFIELD and H. W. FOOTE.

THE mineral that is to be described in the present paper was first brought to our notice in the autumn of 1896 by Mr. Frank L. Nason of West Haven, Conn., who sent a few specimens of it to the Mineralogical Laboratory of the Sheffield Scientific School for identification. When informed that the mineral was a new species Mr. Nason visited the locality for the special purpose of obtaining more material, but so little was found that it seemed best to postpone the investigation until more could be secured. About a year later Mr. E. P. Hancock of Burlington, N. J., sent some Franklin minerals to our laboratory for identification, among them specimens of the new mineral, and on learning the nature of the material he took a keen interest in having it investigated, generously placing at our disposal for that purpose the few specimens he had collected. A short time later Mr. W. F. Ferrier of Ottawa, Canada, also called our attention to an exceptionally fine specimen of the mineral, which he had had the good fortune to find at the locality.

The specimens were all obtained from the dump of one of the new shafts of the Trotter mine, and are supposed to have come from a depth of about one thousand feet. The mineral is associated with transparent prisms of green willemite, a massive variety of brown garnet, phlogopite mica, small yellow crystals of axinite, dull crystals of datolite, and a reddish-brown mineral, occurring in slender prismatic crystals, which is now being investigated, and proves to be a new silicate containing lead, iron and calcium as essential constituents.

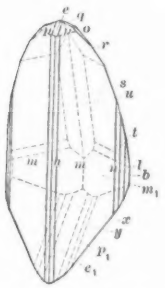
The crystallization is *monoclinic*, and the crystals are especially interesting as they belong to that division of the monoclinic system characterized by a plane of symmetry, but not an axis of symmetry, or to the class of crystals called by Groth* the "*domatische Klasse.*" No form in this class consists of more than two faces, and the pinacoid *b*, 010, is the only one where the faces are parallel. The prevalence of forms without parallel faces gives to the crystals a peculiar *inclined faced* character or appearance, which has suggested the name of the mineral, *clinohedrite* (κλίνειν, incline, and ἕδρα, face). Very few examples of this kind of symmetry have been observed among mineral substances, the best being some crystals of pyroxene described by Williams,† but pyroxene generally

* Physikalische Krystallographie, 3 Auflage, p. 356, 1895.
† This Journal, xxxviii, p. 115, 1889.

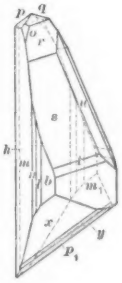
exhibits the normal or most highly developed type of monoclinic symmetry, and specimens which show the lower degree of symmetry are so rarely met with that it seems probable that they are only the result of an accidental development of a part of the crystal faces.

The crystals of clinohedrite on a specimen sent to us by Mr. Hancock were exceptionally fine and well adapted for crystallographic study. They were about 4^{mm} long, and from 2 to 3^{mm} in diameter, and had the habit represented in figs. 1 and 2, the

1.

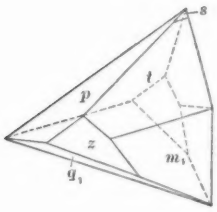


2.



latter being drawn with the pinacoid *b*, 010, in front. They were generally attached at the end represented as the lower one in the figures, and the forms at that end, when they could be observed, were rounded and graded into one another so that

3.



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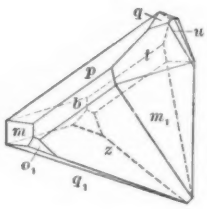

it was difficult to decide what ones were present and how they should be represented in the figure. At the upper, or free ends of the crystals, however, the faces were exceptionally perfect, and gave beautiful reflections. The crystals on the specimens sent by Mr. Nason were not so well suited for crystallographic study, several of the forms being striated and rounded, and it was so difficult to obtain satisfactory measurements that

the relations of the forms did not become wholly clear until the crystals from Mr. Hancock's specimen had been studied. Some of the crystals were 3^{mm} in diameter, and figs. 3 and 4, drawn in the same position as fig. 2, will serve to exhibit the curious habit which they present.

The position which has been adopted seems well suited for representing the forms of the crystals which are given in the following table:

b, 010	n, 120	p, 111	r, $\bar{3}31$	o, $\bar{1}31$
h, 320	l, 130	p_1, $\bar{1}1\bar{1}$	s, $\bar{5}51$	o_1, $13\bar{1}$
m, 110	e, 101	q, $\bar{1}11$	t, $\bar{7}71$	x, $\bar{1}3\bar{1}$
m_1, $\bar{1}10$	e_1, $\bar{1}0\bar{1}$	q_1, $11\bar{1}$	u, $\bar{5}31$	y, $\bar{1}2\bar{1}$

The form z, figs. 3 and 4, is probably $\bar{1}6\bar{1}$, but no measurements could be obtained from it.

The axial ratio was derived from the measurements marked by an asterisk in the accompanying table, and is as follows:

$$a:b:c = 0{\cdot}6826:1:0{\cdot}3226,\ \beta = 100 \wedge 001 = 76^\circ\ 4'$$

Following is a list of measurements with the calculated angles:

	Calculated.	Measured.	Calculated angle on b, 010.	Measured angle on b, 010.
$m \wedge m$, $110 \wedge 1\bar{1}0$ =	67° 2′	66° 57′	56° 29′	56° 29′*
$h \wedge h$, $320 \wedge 3\bar{2}0$ =	47 38	----	66 11	65 5
$n \wedge n$, $120 \wedge 1\bar{2}0$ =	105 54	----	37 3	37 12
$l \wedge l$, $130 \wedge 1\bar{3}0$ =	126 34	----	26 43	26 55
$p \wedge p$, $111 \wedge 1\bar{1}1$ =	29 8	29 8*	75 26	----
$q \wedge q$, $\bar{1}11 \wedge \bar{1}\bar{1}1$ =	34 52	34 49	72 34	72 36
$r \wedge r$, $\bar{3}31 \wedge \bar{3}\bar{3}1$ =	63 15	62 56	58 $22\frac{1}{2}$	----
$s \wedge s$, $\bar{5}51 \wedge \bar{5}\bar{5}1$ =	67 43	67 43	56 $8\frac{1}{2}$	56 20
$t \wedge t$, $\bar{7}71 \wedge \bar{7}\bar{7}1$ =	68 32	----	55 44	----
$u \wedge u$, $\bar{5}31 \wedge \bar{5}\bar{3}1$ =	43 52	44 6	68 4	68 0
$x \wedge x$, $\bar{1}3\bar{1} \wedge \bar{1}\bar{3}\bar{1}$ =	75 52	----	52 4	51 56
$y \wedge y$, $\bar{1}2\bar{1} \wedge \bar{1}\bar{2}\bar{1}$ =	54 56	----	62 32	----
$p \wedge e$, $111 \wedge 101$ =	14 34	14 36		
$m \wedge p$, $110 \wedge 111$ =	51 54	51 54*		
$p \wedge q$, $111 \wedge \bar{1}\bar{1}1$ =	58 37	58 29		
$q \wedge r$, $\bar{1}11 \wedge \bar{3}31$ =	36 21	36 20		
$r \wedge s$, $\bar{3}31 \wedge \bar{5}51$ =	12 45	12 44		
$s \wedge t$, $\bar{5}51 \wedge \bar{7}71$ =	5 50	5 47		
$y \wedge e_1$, $\bar{1}2\bar{1} \wedge \bar{1}0\bar{1}$ =	27 28	27 42		
$b \wedge o$, $010 \wedge \bar{1}31$ =	46 43	46 43		

The cleavage is perfect parallel to the pinacoid b, 010, but is not often observed. The hardness is 5·5 and the specific gravity 3·33. Many of the crystals are transparent, and the color varies from amethystine to nearly colorless or white.

The crystals exhibit very distinctly the phenomenon of pyro-electricity when tested with the red oxide of lead and sulphur method described by Kundt.* On cooling a crystal of the type represented by figs. 1 and 2 the p, e, and the upper extremities of the m faces in front became positively electrified and attracted the particles of sulphur, while the diagonally opposite faces x, y, p_1, e_1, and the lower extremities of m, became negatively electrified and attracted the red oxide of lead.

A section parallel to the pinacoid 010 when examined in polarized light showed an extinction of about 28° from the vertical axis in the obtuse angle β, and this direction corresponds to b. The plane of the optical axes is at right angles to 010. The crystallographic axis b is the obtuse bisectrix, and corresponds to c. The double refraction is not very strong, and is negative.

Material for the chemical analysis was first carefully selected by hand picking, and was then further purified by pulverizing and separating by means of the barium mercuric iodide solution. That portion which was used for the analysis varied in specific gravity between 3·344 and 3·327.

The method of analysis was as follows: Water was determined as loss on ignition, and the residue, after fusion with sodium carbonate, was dissolved in hydrochloric acid. The solution was evaporated twice to separate the silica, and in the filtrate from the silica the acid was neutralized with a slight excess of ammonia, formic acid of specific gravity 1·12 was added so as to make about one-fourth of the final volume, and hydrogen sulphide was passed into the hot solution until the zinc was precipitated. After filtering, the zinc sulphide was dissolved in hydrochloric acid, and the zinc reprecipitated as carbonate and weighed as oxide. In the filtrate from the zinc the small quantities of iron and alumina were precipitated twice with ammonia. To the filtrates acidified with hydrochloric acid bromine was added, and on making alkaline and heating to boiling all of the manganese was precipitated, but as it carried a little calcium it was redissolved, precipitated from an acetic acid solution with bromine, and finally determined as pyrophosphate. Calcium and the trace of magnesium were separated and determined in the usual manner.

The results of the analysis by Foote are as follows:

* Ann. d. Phys. u. Chem., xx, p. 592, 1883.

	I.	II.	Average.	Ratio.			Theory for $H_2CaZnSiO_5$.
SiO_2	27·14	27·29	27·22		·454	0·97	27·92
ZnO	37·43	37·46	37·44	·462	·469	1·00	37·67
MnO	·49	·50	·50	·007			
CaO	26·31	26·19	26·25	·469	·471	1·00	26·04
MgO	·07	·08	·07	·002			
H_2O	8·53	8·59	8·56	·476		1·01	8·37
$(Fe.Al)_2O_3$	·26	·31	·28				
			100·32				100·00

The ratio of $SiO_2 : (Zn+Mn)O : (Ca+Mg)O : H_2O$ is very nearly 1 : 1 : 1 : 1, from which the formula $H_2ZnCaSiO_5$ is derived, in which the zinc and calcium are replaced to a slight extent by manganese and magnesium respectively. The formula may also be written $(ZnOH)(CaOH)SiO_3$, and that hydroxyl is present is proved by the fact that water is not expelled much below a faint redness The formula is analogous to that of calamine $H_2Zn_2SiO_5$ or $(ZnOH)_2SiO_3$.

The pyrognostic properties are as follows: In the closed tube at a gentle heat the mineral is unchanged, but at a temperature approaching faint redness it exfoliates, whitens and gives off water. Heated before the blowpipe the mineral exfoliates at first, and then fuses at about 4 to a yellowish enamel. A coating of zinc oxide is obtained when the mineral is heated alone or with a little sodium carbonate on charcoal. The powdered material dissolves readily in hydrochloric acid, and gelatinous silica is obtained when the solution is evaporated.

In conclusion we take great pleasure in expressing our sincere thanks to Messrs. F. L. Nason and E. P. Hancock, who have generously placed at our disposal all of the specimens of this rare mineral which they have been able to collect.

Mineralogical-Petrographical Laboratory,
Sheffield Scientific School, March, 1898.

Art. XL.—*On Rhodolite, a new variety of garnet;* by W. E. Hidden and J. H. Pratt.

During the past fifteen years there has been found from time to time, over a very limited area of western North Carolina, a variety of garnet which is strikingly beautiful and quite novel in several respects. It has been called "rose-garnet," almandine and has also received other strictly local names: among mineralogists it has excited unusual interest and admiration.

The peculiarities which distinguish this garnet from the ordinary occurrences of the species are: its variety of shades and tints, for the most part similar to those belonging to the rhododendrons and roses; its surprisingly small amount of coloring matter; its gem-like transparency; its freedom from internal imperfections, microscopic inclusions and striæ, all so universally characteristic of common garnets; also its remarkable brilliancy when cut as a gem. There is but one variety of garnet now known, which approaches it in this last respect, when in the gem form, and that is the *green* demantoid of Siberia, which often vies with the diamond in its luster and dispersive effect upon light. Most garnets are beautiful only by *transmitted* light and then exhibit only dark shades of color, while these new garnets give most beautiful effects of brilliant and varied coloring by *reflected* light alone; thus proving the uncommon purity and great clearness of this new material.

These garnets occur as one of the pebbly constituents of the gravel-beds and they are found much after the manner of mining for "placer" gold, where hydraulic processes are used. The exact place or ledge from which they have been derived has not, as yet, been discovered, but similar material of an inferior grade has been found *in situ* at one place accompanied by much pyrite and biotite.

The locality is situated in Macon County, North Carolina, upon a brook known as Mason's Branch. This brook flows southwestward from Lyle Knob (a spur of the Cowee Mountains). Franklin, the county seat, is about six miles distant. The associated minerals, in the gravels, are: Quartz, rarely as isometric pseudomorphous dodecahedrons; small rough garnets of a dark pyrope nature; small corundum crystals, of pale blue, amethystine and pink shades, sometimes with a distinct ruby tendency; spinel, the pleonaste and gahnite varieties; bronzite (transparent); iolite (colorless); cyanite; fibrolite; hornblende; staurolite (often clear and glassy); rutile; menaccanite; chromite (rare); monazite (rarely green); zircon; gold

and sperrylite in minute quantities, and also several as yet unidentified species. It is our intention to publish a description of some of these accompanying minerals in the near future.

As yet no crystals of the new garnet have been found, all the material occurring as rolled pebbles, fragmentary masses or as highly etched (naturally corroded) pieces. The predominant color is a pale rosy tint inclining to purple, and some carefully selected pieces of this character, which showed no inclusions under the magnifying glass, were used for the chemical analysis.

In the analyses, silica and the bases were determined by the well known methods. Ferrous and ferric oxides were determined by the method described by one of us.* The results of the analyses are given below together with the specific gravity which was determined upon two separate samples.

Specific gravity = 3·837—3·838.

	I.	II.	III.	Average.	Ratio.	
SiO_2	41·54	41·65		41·59	·693	= 3·
Al_2O_3		23·26	23·10	23·13	·226	·237 = 1·02
Fe_2O_3	1·88	1·92		1·90	·011	
FeO	15·48	15·63		15·55	·216	
MgO		16·90	17·48	17·23	·437	·669 = 2·89
CaO	1·02	·86		·92	·016	
				100·32		

The ratio of $R''O : R'''_2O_3 : SiO_2$ is nearly 3 : 1 : 3, which would give the general formula $3R''O . R'''_2O_3 . 3SiO_2$ or $R''_3R'''_2(SiO_4)_3$ which classifies this mineral as one of the garnets. The ratio of MgO to FeO (·437 : ·216) is almost exactly 2 : 1, which would indicate that the mineral is composed of two molecules of a magnesium-aluminum garnet (pyrope) and one molecule of a ferrous iron-aluminum garnet (almandite). The theoretical composition calculated for this ratio is given below, together with the analysis after substituting for Fe_2O_3 its equivalent of Al_2O_3 and for CaO its equivalent of MgO and then recalculating to 100 per cent:

	Analysis recalculated.	Theory for $2Mg_3Al_2(SiO_4)_3 . Fe_3Al_2(SiO_4)_3$.
SiO_2	41·76	41·48
Al_2O_3	24·41	23·50
FeO	15·62	16·59
MgO	18·21	18·43
	100·00	100·00

* J. H. Pratt in this Journal, vol. xlviii, 1894, p. 149.

Although the agreement of the analysis, as deduced, and the theory is not absolutely close, it must still be regarded as on the whole satisfactory and the formula $2Mg_3Al_2(SiO_4)_3 . Fe_3Al_2(SiO_4)_3$ may be accepted as expressing the composition of this mineral.

The analysis proves that this garnet is not almandine nor wholly pyrope and is distinctive enough in color alone to merit a varietal name. We, therefore, propose the name of *Rhodolite*, from the two Greek words *ῥόδον*, *a rose*, *λίθος*, *a stone*, as an appropriate name for this new gem. This name has been selected as describing its most prominent character, namely, its delicate rose-like color. It will be seen that these new gems are very unlike all kinds of garnets hitherto described.

Cowee Valley, N. C., March 14, 1898.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Solubilities of Liquids.*—Several years ago Alexéeff called attention to the solubility of liquids in each other and showed that in the case of mixtures of aniline, phenol and water, it is often difficult to distinguish between the solvent and the dissolved substance. The same condition has now been observed by Aignan and Dugas in the case of mixtures of acetic acid and benzene, which in various proportions become homogeneous at different temperatures. Thus for example:

Acetic acid.....	30cc	40cc	50cc	60cc	70cc
Benzene	70cc	60cc	50cc	40cc	30cc
Temperature of homogeneity	102°	75°	50°	30°	2·5°

The authors show that if V_a and V_b represent the respective volumes of two liquids A and B, which are introduced into the sealed glass tube, if α and β be their reciprocal solubility coefficients, and if V_1 and V_2 be the volumes of the two layers of liquid respectively, A saturated with B and B saturated with A, then

$$\frac{V_1}{V_2} = \frac{1+\beta}{1+\alpha} \cdot \frac{V_a - \alpha V_b}{V_b - \beta V_a}$$

They also point out that a similar relation holds if masses be taken in place of volumes. It follows therefore that when the temperature varies, if α tends towards the value V_a/V_b, the numerator of the first member, V_1 should tend towards zero; while if β tends towards the value V_a/V_b, then V_2 should tend towards zero. Hence it is necessary to notice toward which extremity of the tube the surface of separation of the liquid disappears on heating. With the mixtures named above, when the per cent of acetic acid is 30, 40 or 50, the surface of separation tends towards the bottom of the tube; so that saturated solutions of acetic acid in benzene occur at 75° and 50°; while with 60 and 70 per cent of acetic acid, the disappearance of the surface of separation tends towards the top of the tube; so that at 30° and 2·5°, the solutions are saturated solutions of benzene in acetic acid.—*C. R.*, cxxv, 498–500, October 1897. G. F. B.

2. *On the Thermodynamics of the Swelling of Starch and the Determination thereby of its Molecular Mass.*—An investigation upon the thermodynamics of the phenomenon of the swelling of starch has been made by Rodewald. He defines the term "swelling" to be the absorption of water or other liquid by a solid substance which does not show either visible or microscopic pores. The expression which he has deduced from thermodynamical considerations, for the heat set free, in terms of the

change of specific volume, is $r = T\,[dp/dt(s'-s)-y]$. The experimental work was done mostly upon starch. This substance, when air dried, was found to contain about 16·33 per cent of water. By means of an ice calorimeter, the heat which is produced by soaking in water starches having originally different amounts of moisture was determined, the results being tabulated and plotted as a curve. The contraction in volume as a function of the percentage of water, was also noted and plotted; the curve being similar to the heat curve. From the values of the heat change and the volume change for the dry and moist starch, dp/dt and y in the equation given above are obtained; thus giving the numerical equation $r = 273\,(s'-s)\,1{\cdot}75 - 0{\cdot}00507$. Next, the author deduces a relation between the heat of swelling (and hence the volume change) and the water content and thus derives the equation $\log\,(s'-s)\,w = 0{\cdot}8-2-0{\cdot}0423\,w$. Consequently when $w = 31{\cdot}63$, $\gamma = 0$. An expression given by Kirchhoff for the vapor pressure of sulphuric acid solutions is used to calculate that of the starch; the result being 4·5594 for a content of 31·63 per cent of water. The author deduces from this calculated value of the vapor pressure, the number 4370 as the molecular mass of starch; corresponding to the formula $C_{162}H_{270}O_{135}$. Moreover, he finds the expansion-coefficient to be a linear function of the content of water. And he calculates the attractive force between dry starch and moisture as 2073 kilograms per square centimeter.—*Zeitschr. Phys. Chem.*, xxiv, 193–218, October 1897.

G. F. B.

3. *On the Evolution of Oxygen during Reduction.*—When rubidium dioxide is reduced by hydrogen, oxygen is evolved; a fact which Erdmann attempted to explain by supposing the intermediate formation of hydrogen peroxide. Frenzel, Fritz, and Victor Meyer have now made experiments to test this explanation, in some of which the formation of hydrogen peroxide was not possible. Thus on heating potassium peroxide to the softening point of glass (the vessel being of silver) in a current of air, no oxygen is evolved. But when heated in carbon monoxide, carbon dioxide, or hydrogen, to the boiling point of sulphur, a considerable amount of oxygen is set free. Now in the case of carbon monoxide, as well as in that of the dioxide, the formation of hydrogen peroxide as an intermediate product is impossible. So that the three reactions appear to be analogous:

$$K_2O_4 + CO = K_2CO_3 + O_2$$
$$(K_2O_4)_2 + (CO_2)_2 = (K_2CO_3)_2 + (O_2)_2$$
$$K_2O_4 + H_2 = (KOH)_2 + O_2$$

Again, silver oxide decomposes when heated to 250° in a current of air; but in hydrogen it yields free oxygen even when heated only to the boiling point of water. Indeed, it evolves oxygen in carbon monoxide even at the ordinary temperature; the fact being that a portion of the oxide in reduction evolves sufficient heat to raise the temperature of the rest above the decomposing

point. Potassium permanganate acted similarly. This salt decomposes at 218° in air; but in hydrogen it begins to evolve oxygen at 155° and gives it off freely at 182°. Barium peroxide does not give off oxygen during reduction.—*Ber. Berl. Chem. Ges.*, xxx, 2515–2519, November 1897. G. F. B.

4. *On Chromium Tetroxide and Perchromates.*—It has been observed by WIEDE that on cautiously treating with ammonia the blue solution obtained by extracting a mixture of hydrogen peroxide and chromium trioxide with ether, the color gradually disappears, and on sufficient cooling the underlying aqueous layer takes a deep brown color and deposits a greenish-brown precipitate on standing. On dissolving this in warm 10 per cent solution of ammonia, and allowing it to cool, pale brown needles separate having the composition $(NH_3)_3CrO_4$. The new compound dissolves in water, suffering partial decomposition, evolves oxygen when treated with strong acids and explodes when heated. If treated with alkalies or if the ethereal solution itself is treated with a concentrated solution of potassium or sodium hydrate instead of ammonia only alkali chromates are formed. On using substituted ammonias, corresponding perchromates are formed. When for example the ethereal solution is treated with pyridine and the ether is evaporated in a rapid current of air, blue scales are produced. And if one of these be placed in the ethereal solution after the pyridine has been added, long dark blue glistening prisms gradually form having the composition $H.C_5NH_5CrO_5$. These crystals are so unstable that they explode violently even at the summer temperature. But if dry, they can be kept for weeks in the cold; though when moist they decompose rapidly. It is soluble in most of the neutral organic solvents, and is acted upon only gradually by potassium permanganate in acid solution. Aniline, when added to the ethereal solution of perchromic acid, gives, on diluting the solution with an equal volume of light petroleum naphtha, dark red crystals, $H.NH_2Ph.CrO_5$ resembling potassium permanganate. It is even more explosive than the pyridine compound.—*Ber. Berl. Chem. Ges.*, xxx, 2178–2189, October 1897. G. F. B.

5. *On Potassium Percarbonate.*—It has been shown by Constam and von Hansen that in very concentrated solutions, the alkali carbonates will dissociate into the ions $\overset{+}{M}$ and $\overset{-}{MCO_3}$ the latter uniting, on being set free by electrolysis at the anode, to form percarbonates $M_2C_2O_6$. If a solution of potassium carbonate be electrolyzed the evolution of oxygen decreases as the temperature falls, becoming almost nil at −10°. At the same time in place of the hydrogen-potassium carbonate which at first forms at the anode, there is produced a bluish amorphous powder consisting of potassium percarbonate. VON HANSEN has further studied this reaction and finds that if the density of the solution of potassium carbonate surrounding the anode is not allowed to fall below 1·52, small temperature variations do not markedly affect the yield, even when it rises to 0°. When the concentration falls,

even a very little below saturation, the yield falls off greatly. High current density at the anode is also essential. When this is only 0·5 to 2 amperes per square decimeter, the product contains only from 25 to 55 per cent of percarbonate; while with a density of from 30 to 60 amperes per square decimeter, it may contain as much as 85 to 95 per cent. By allowing the saturated solution of potassium carbonate to flow slowly in at the bottom of the anode compartment of the electrolytic cell, the best results are obtained. The solution which has already undergone electrolysis floats on this, the solid percarbonate remaining suspended in it slowly flows away; and the percarbonate is collected and dried on a porous plate. From 2·2 to 2·4 grams of percarbonate, containing 87 to 93 per cent, is obtained per ampere hour. When dry the percarbonate is only slowly decomposed at 100°, its rapid decomposition requiring 200° to 300°. In aqueous solution, it decomposes slowly at the ordinary temperature, rapidly at 45°. When perfectly dry, it may be preserved almost without change. It is very little soluble in alcohol, but extremely soluble in water. It may be purified by digestion at −5° to −10° with concentrated potash solution which dissolves the bicarbonate. The remaining solid after washing with alcohol contains 95 to 99 per cent of percarbonate.—*Zeitschr. Elektrochem*, iii, 137144, 445–448, Oct. 1896, April 1897. G. F. B.

6. *On the Formation of Natural Petroleum and the Spontaneous Polymerization of Hydrocarbons.*—While the hypothesis that natural petroleums have for the most part been produced by the distillation under pressure of animal fats, and hence accounts for their small content of nitrogen, it fails to account for the high molecular mass, boiling point and density of certain of its constituents; it being well known that the product of the artificial distillation of such fats are mainly low boiling light hydrocarbons. ENGLER now proposes to ascribe this high molecular mass, boiling point and density to the gradual polymerization of the light hydrocarbons first formed, and has obtained considerable evidence of such changes. Thus samples of Galician petroleum increased in density by 0·0011—0·0015 in about three weeks, while a Javanese petroleum increased by 0·01 in a few days. Distillates from coal tar showed similar results. The fractions obtained by the distillation of fats under pressure were then examined and proved to undergo a similar condensation. In one case the density increased by about 0·002 in a month; while in five other cases, there was an increase of density in nine years of 0·016. Since the time which has elapsed since the production of petroleum is very great, it appears probable that its present high density may have been acquired in this way.—*Ber. Berl. Chem. Ges.*, xxx, 2358–2365, October 1897. G. F. B.

7. *The Sun's Place in Nature;* by SIR NORMAN LOCKYER, K.C.B., F.R.S., etc., 8vo, pp. xvi, 360. London, 1897 (The Macmillan Co., Limited).—This book is a summary of the evidence which its industrious author has been for many years collecting as to

the exact position which our sun, judged by spectroscopic evidence, should occupy among its fellows. In his previous volume, "The Meteoritic Hypothesis," he has brought forward the arguments for believing that the primordial matter was not, as the Nebular Theory assumes, an intensely heated glowing gas, but was a meteoric swarm or a congeries of such swarms, which by condensation and consequently closer and more frequent impact, produced an increasing heat and continued to rise in temperature until the loss became equal to the gain. Hence he says: "The idea which one arrives at by a discussion of all the spectroscopic facts is that we begin with a condition in which meteorites in swarms and streams are very far apart, and from the collisions of these a spectrum results which gives us bright flutings and lines, in other words the spectrum of the nebulæ; when they become a little more dense, we get the bright line stars; and as they become denser still we find the stars with a mixture of bright and dark flutings. Then still more condensation and dark lines and at length the highest temperature of all; after which begins a descent on the other side till at last we end in cool dark bodies like the earth and moon." Of his five groups, the author selects the Orion nebula as the type of the first, α Herculis as the type of the second, α Cygni as that of the third, Sirius as that of the fourth and Arcturus as that of the fifth. The maximum temperature being reached in the fourth group, those stars in previous groups are rising and those in succeeding groups are falling in temperature, our own sun belonging to the fifth. While broadly speaking the hypothesis before us is a real advance over its predecessor, yet as to matters of detail it has not received, we believe, the general assent of astronomical spectroscopists. Thus, for example, it is extremely difficult if not in many cases impossible to distinguish a star of the third group from one of the fifth; i. e., a star which is supposed to be rising in temperature from one which is falling. Still the book places the arguments in a clear light and cannot fail to be of use in helping us to reach a final conclusion. G. F. B.

8. *Nature of Röntgen Rays.*—Professor G. G. Stokes states his belief that these rays are transverse vibrations of the ether, and that the cathode rays are streams of rapidly-moving particles. He conceives of the apparent transparency of thin aluminum plates to the cathode rays as the result of a process similar to that which happens to a copper plate immersed in a sulphate of copper solution which is undergoing electrolysis. On one side copper is separated, on the other is dissolved. The deflection of the cathode rays by magnetic and electrostatic force, Stokes regards as a great objection to their being considered light rays. According to his views the Röntgen rays are impulses, and not vibrations.—*Manchester Memoirs*, 41, Part iv, 1896–97. J. T.

9. *Impulse theory of X-rays.*—Following Professor Stokes, Professor J. J. Thomson has elaborated the impulse theory of X-rays from the point of view of the electro-magnetic theory of light. When a rapidly-moving electrified particle is stopped,

its electro-magnetic energy may be transformed into waves which are identical with light waves. Professor Thomson gives the equations of condition for such a moving particle, and shows that they lead to the conclusion that in the X-ray phenomena two waves result from the electric impulses, one of which is a spherical wave and the other a plane wave. The dimensions of the plane waves are extremely small. The X-ray effects are therefore produced at the surfaces where the electrified moving particles are stopped.—*Phil. Mag.*, February, 1898. J. T.

10. *Acoustic phenomena in the Electric Arc.*—The initial resistance of the voltaic arc is largely determined by the density of the surrounding air. If a sound wave travels through the gaseous layer of the voltaic arc, there arise periodic changes in the transitional resistance, and consequently similar periodic changes result in the current strength. These changes can be studied in neighboring telephone circuits. H. Th. Simon has made a careful study of these phenomena, and makes a calculation of the change of temperature produced by a sound wave passing through the heated gas of the arc; and also of the change of pressure which might result in the gas. Lord Rayleigh has estimated that the least change of pressure which can produce an appreciable tone in ordinary air has the value $\Delta p = 6 \cdot 10^{-9}$ atmosphere. Simon finds $\Delta p = 9 \cdot 10^{-5}$ atmosphere, and states that the discrepancy probably arises from the presence of harmonics. Recent experiments in the Jefferson Physical Laboratory with a large storage battery show that the discharge of this battery through vacuum tubes is accompanied by a high note which rises in pitch as the resistance external to the tube is increased.— *Wied. Ann.*, No. 2, 1898, pp. 233–239. J. T.

11. *Time of vibration of very high notes.*—It is well recognized that the measurement of high notes is very difficult and Ant. Appunn discusses the conditions for the investigation of such high periods, and describes a series of pipes constructed by him which gave vibrations extending from 2500 vibrations a second to 50,000 per second. The length of the pipe which gave 50,000 per second is 1·28 millimeters.— *Wied. Ann.*, No. 2, 1898, pp. 409–416. J. T.

12. *Electrical excitation.*—Many attempts have been made to explain contact electricity by the laws of electrolysis, and thus to connect it with the chemical and physical nature of the substances. Alfred Coehn discusses the various theories of ions and ion concentration, and formulates the law that matter of higher dielectric constants charge themselves positively by contact with matter of lower dielectric constants. There are notable exceptions to this law.— *Wied. Ann.*, No. 2, 1898, pp. 217–232. J. T.

13. *A Manual of Experiments in Physics; Laboratory Instruction for college classes;* by Joseph S. Ames and William J. A. Bliss.—This volume is a companion to the Theory of Physics, by Professor Ames, which was noticed in the number of this *Journal* for June, 1897. The long experience of the author as a teacher of

physics, which enabled him in this first volume to develop with unusual clearness and method the principles involved in physical phenomena, has now aided him in the description of a series of laboratory experiments for college classes. This work, in the preparation of which he has been associated with Dr. Bliss, is on a decidedly higher level than most of those which have been published hitherto. The experiments are selected with judgment and the method of presentation has much to be recommended, not only in the fullness and accuracy of statement but still more as regards the prominence given to the statement of the general theory involved in each and the object for which it is performed. In developing these points, reference is constantly made to the companion volume, and the student who uses the two works conscientiously cannot make the mistake so common of performing an experiment blindly, without understanding why it has been done or what physical principles it illustrates. Each experiment is accompanied by a practical illustration, drawn out numerically in full, and a series of questions and problems follow; these last bear particularly upon the sources of error involved and the degree of accuracy possible in each case.

II. Geology and Mineralogy.

1. *Recent Publications of the U. S. Geological Survey.**—The Eighteenth Annual Report for 1896–7 has five parts, of which Part i, *Report of the Director;* Part v, *Mineral Resources,* and two papers of Part iii, *Economic Geology,* have already been issued. The remaining papers of Part iii, and Part iv, *Hydrography,* will soon appear. Those of Part ii are of a theoretical nature and will appear last. The report of the Director with an appendix on Triangulation and Spirit leveling contains 440 pages with two maps showing the condition and progress of astronomic location, primary triangulation, traverse and precise leveling, topographic surveys, and gauging stations. The total appropriation for the work of the Survey during the year was $568,690, of which $184,200 was for topography, $118,700 for geology, $14,000 for paleontology, $10,000 for chemistry, $50,000 for hydrography, and $30,000 for preparation of report on mineral resources. There were thirty geological field parties in as many States and Territories. Most of the geologists continued the areal and structural work of former years. N. S. Shaler completed his investigations on Cape Cod and took up the Mesozoic coal basin near Richmond, Va.; B. K. Emerson extended his work in Mass.; T. Nelson Dale in eastern New York and Vt.; J. F. Kemp in the Adirondack region; W. H. Hobbs in western Mass. and Conn.; J. E. Wolff, assisted by A. H. Brooks, coöperating with the State Survey in New Jersey; M. R. Campbell, assisted by J. A. Taff and W. C. Mendenhall, in Kentucky and

* Issued since May, 1897. See lists in this Journal for Aug. 1897, page 155, and for Nov. 1897, page 392.

Tenn.; C. W. Hayes in Ga. and Ala.; Arthur Keith in Va., Md. and N. C.; W. B. Clark in N. J., Md. and Del.; N. H. Darton in the District of Columbia, Md. and Va., besides a large amount of hydrographic work in S. Dak. and Nebraska; C. R. Van Hise, assisted by W. S. Bayley, J. M. Clements and S. Weidman, in the Menominee iron region of Lake Superior; R. T. Hill and T. W. Vaughan in Texas and Indian Territory; W. H. Weed assisted by L. V. Pirsson in Montana and Arkansas; R. C. Hills in Colo.; C. W. Cross, assisted by A. C. Spencer and C. W. Purington, in Colo.; W. Lindgren in Idaho; H. W. Turner, A. C. Lawson and J. C. Branner in California; J. S. Diller, assisted by A. J. Collier, in Oregon; Bailey Willis, assisted by I. C. Russell and G. O. Smith, in Washington. Special surveys were made in the Yukon gold region of Alaska by J. E. Spurr, H. B. Goodrich and F. C. Schrader; S. F. Emmons, assisted by G. W. Tower, made a special study of the mining district of Butte, Montana; G. H. Eldridge surveyed the phosphate rocks of Florida; C. D. White extended his studies of the coal floras of the Carboniferous in Ky., Tenn., Penn. and Ohio; T. C. Chamberlin, in general charge, assisted by Frank Leverett, H. B. Kummell, W. C. Alden and J. E. Todd, extended their glacial investigations in Iowa, Mo., Ind., Ills., Ky. and N. Y.; G. K. Gilbert made a special study of the region of the Great Lakes; the Director (C. D. Walcott), assisted by F. B. Weeks, studied the Cambrian in southwest Nevada and California. Of the paleontologists: G. H. Girty studied the Paleozoic in Ohio; T. W. Stanton the animals, and F. H. Knowlton the plants of the Cretaceous in Colorado, Wyoming and Montana; W. H. Dall the Tertiary among the large collections in the Smithsonian Institution; L. F. Ward the Cretaceous Paleobotany in Maryland and Virginia. Thirteen pages of the report are devoted to the hydrographic work at 109 stations in 22 States. The total value of the mineral resources for 1896 was $623,717,288, with only about one-twentieth of the normal annual increase over that of 1895.

The two economic papers of Part iii which have already appeared are:—

Reconnaissance of the Gold Fields of Southern Alaska, with some notes on the General Geology by G. F. Becker, pp. 1–86, 23 plates including 2 maps.

Geology of the Yukon Gold District, Alaska, by J. E. Spurr, with chapter on the History and Conditions of the District to 1897 by H. B. Goodrich, pp. 1–392, and 20 plates including 12 maps, of which 5 in colors are geological.

To meet the great demand for information concerning the gold region of Alaska, a pamphlet of 44 pages with 1 map showing routes of travel and distribution of gold-bearing rocks in Alaska has been issued by the Geological Survey.* It was prepared by S. F. Emmons chiefly from the papers of Spurr and Becker, using the Coast Survey chart T as topographic base.

* See p. 305 of this number.

Bulletin No. 149, *Bibliography and Index of North American Geology, Paleontology and Mineralogy for* 1896, by F. B. Weeks, contains 152 pages. The bibliography consists of papers and references classified by authors. In the index the classification is by subject and thus rendered especially useful.

The following folios have been issued :

No. 31. Pyramid Peak, Colorado, by W. Lindgren.
33. Briceville, Tennessee, by Arthur Keith.
34. Buchanan, West Virginia, by J. A. Taff and A. H. Brooks.
35. Gadsden, Alabama, by C. W. Hayes.
36. Pueblo, Colorado, by G. K. Gilbert.
37. Downieville, California, by H. W. Turner.

The Pueblo Folio of Colorado was prepared for laymen as well as geologists, and is an excellent model of its kind. The structure of the western edge of the great plains is well shown and its geological development described. Among the novel features are tepee buttes, whose form suggests the name and whose origin is ascribed to limestones standing vertically in the Pierre shales. A special sheet illustrates the deformation of the Dakota sandstone. Being very porous, this sandstone is the chief reservoir for underground water. The water resources are shown by a map upon which the areas yielding flowing wells and pumping wells are distinguished, and by contours the depth is indicated at which the water will be found.

Recognizing the important bearing of the hydrographic investigations in charge of N. H. Newell upon the agricultural resources of much of the western country, the work and publications in that line have been greatly extended. Besides the forthcoming Part iv of the Eighteenth Annual, which is devoted exclusively to hydrography, a series of twelve water-supply papers have been issued discussing the probabilities and methods of using to greatest advantage the water-supply of certain districts. J. S. D.

2. *The Gold fields of Alaska.*—Three important contributions to the knowledge of the mineral resources of Alaska have been recently prepared by the United States Geological Survey.* Using these as his chief sources of information, Mr. S. F. Emmons has now prepared a pamphlet† to accompany a map of Alaska showing the known gold-bearing rocks.

*1. Coal and Lignite of Alaska, by W. H. Dall. 17th Ann. Rept. U. S. Geol. Survey, Pt. 1. Washington, 1896.

2. Reconnaissance of the Gold fields of Southern Alaska by Geo. F. Becker. 18th Ann. Rept U. S. Geol. Survey, Part iii, pp. 1–86. Washington, 1898.

3. Geology of the Yukon Gold District, Alaska, by J. E. Spurr with introductory chapter by H. B. Goodrich. Ibid., pp. 101–391.

† Map of Alaska showing known gold-bearing rocks, with descriptive text containing sketches of the geography, geology, and gold deposits and routes to the gold fields, by S. F. Emmons, pp. 1–44. U. S. Geological Survey, Washington, 1898. The base used for the geological map is a part of chart T of the U. S. Coast and Geodetic Survey. Edition of June, 1897.

From this pamphlet we quote at some length below. It contains a brief historical introduction and reference to available literature; a geographical sketch describing the region, the rivers, climatic conditions and routes to the Klondike. Then follow some twenty pages sketching the geological features. The latter are more elaborately described in the second and third reports named, by Messrs. G. F. Becker and J. E. Spurr, and the coal deposits are described in Mr. Wm. H. Dall's report.

The original deposits of gold, or quartz veins have been noted in the coastal region as well as in the interior.

"At present, so far as known, it is only in the coastal region that deep mining is being carried on in gold-bearing veins. Here it has become a well-established industry, and many large quartz mills are running on the ore extracted from these veins. The principal deposits are found in a belt somewhat over 100 miles in length on the seaward slope of the mainland, reaching from Sumdum on the southeast past Juneau to Berners Bay near Seward on the northwest. This belt may be also considered to include the deposits on Admiralty and other islands. A second belt, further west, is represented by the deposits on the western side of Baranof Island, not far from Sitka. The ores, though not always exceptionally rich, are worked at a good profit because of the natural facilities of the region for cheap reduction. The most notable instance of this is the great Alaska-Treadwell mine, which has extracted over seven million dollars' worth of gold from an ore carrying $3.20 a ton, which is worked at an average cost of $1.35.

The deposits occur in metamorphic slates, diabases, and granites, all similar to the rocks of the auriferous belt of California, and probably, like those, they are of post-Jurassic age.

At Uyak Bay, on Kadiak Island, gold deposits in slates are being worked, and the gold-bearing beach sands of the western end of that island and at Portage Bay and the Ayakulik River on the neighboring mainland are apparently derived from metamorphic slates associated with granite, so that it is possible that these more recent gold-bearing rocks extend that far westward. On Unga Island, of the Shumagin group, still further west, gold occurs in eruptive andesites of Tertiary age, and several mines have been opened on these deposits, the most important of which is the Appollo, one of the most successful in the province. . . .

In the Yukon Basin the gold, so far as known at present, is derived from a much older series of rocks, for the gold-bearing slates of the coastal region have not yet been recognized there. While the exact age of these gold-bearing rocks has not yet been determined, they are known to be older than the limestones supposed to represent the Carboniferous and Devonian formations of the Cordilleran system; hence they are probably pre-Paleozoic, and in part are possibly as old as the Archean.

These rocks have been classified by Spurr as follows:

Later Tertiary beds } Tertiary.
Kenai series }
Mission Creek series—Cretaceous.
Tahkandit series—Carboniferous and Devonian.
Rampart series }
Fortymile series } ? pre-Paleozoic.
Birch Creek series }
Basal granite-schist.

Birch Creek series.—Resting upon the fundamental granite is a series of rocks, roughly estimated as possibly 25,000 feet in thickness, named the Birch Creek series, from the place of their typical occurrence. They consist mainly of quartzitic rocks, generally thin-bedded or schistose, so that they pass into mica-schist; in some places they contain carbonaceous matter and develop graphitic schists. There are also bands which probably originated as intrusive rocks, but which by compression have become schistose like the other members. These rocks have abundant quartz veins; they are generally parallel to the schistosity or bedding, small, and not persistent, but some cross the bedding and are then wider. They carry gold with abundant pyrites, and sometimes galena. They are often broken and faulted.

Fortymile series.—Younger than the Birch Creek series, but in general closely associated therewith, is another thick series of rocks, called the Fortymile series because of their development on Fortymile Creek. They are characterized by alternations of beds of marble, from a few inches up to 50 feet in thickness, with quartzites, which pass into micaceous, hornblendic, or garnetiferous, and sometimes graphitic schists. They are traversed by abundant dikes of eruptive rock, mostly granites and diorites. Two sets of quartz veins are developed in these rocks: (1) an older set, which are generally parallel to the schistosity or lamination, like those in the Birch Creek series, and like them are broken by later movements and carry pyrite and occasionally galena; (2) a set of larger veins, which form an apparent transition from dikes of aplite. They cut across the bedding and are not disturbed by later rock movements, hence are younger in age.

Rampart series.—This still later series is primarily distinguished from the preceding by the darker color of its rocks, which are dark-green when fresh and become a dark-red by weathering. They consist largely of basic eruptive materials, beds of diabase and tuffaceous sediments, with hard green shales and some limestones containing glauconite. They also contain novaculites and jasperoids, or secondary quartzose rocks which are at times glauconitic. Serpentine and chlorite are frequent alteration products. These rocks also contain a few quartz and calcite veins, which are generally developed along shear zones. The basic character of these rocks and their large content of pyrite seem favorable to the concentration of ore deposits; but the observed veins are younger than the joints and shear planes,

which were probably produced by the rock movements that crushed the veins of the older series, and assays of their ores have as yet shown but insignificant amounts of gold and silver. These veins, like those in the granite, are much less abundant than those in the Birch Creek and Fortymile series; hence it is thought that the latter are probably the principal source of gold in the placers.

The younger rock series noted are, briefly, the following:

Tahkandit series.—This is a temporary division made for purposes of mapping and consists of limestones, sometimes white and crystalline, generally green or black, alternating with shales. In certain localities, notably on the Tahkandit River, it has conglomerates carrying greenish pebbles supposed to be derived from the rocks of the Rampart series; thus an unconformity or erosion interval is suspected. In the beds of this series have been found fossils of Carboniferous age and plants of Devonian aspect.

Mission Creek series.—Later than the Tahkandit series, but, like it, not very well defined, is the Mission Creek series, consisting of shales and thin-bedded limestones with gray sandstones. Locally there are thin beds of impure lignite and at the base a conglomerate containing pebbles not completely rounded derived from older rocks in the neighborhood, which sometimes carries gold. The beds of this series are sometimes altered and sharply upturned and folded, but generally have a rather fresh appearance. In the neighborhood of shear zones they are impregnated with pyrite and carry small quartz veins. The limited exploration of these rocks has developed no important deposits of mineral. The age of the beds is as yet uncertain, but they are in part as late as Cretaceous. They sometimes overtop the Tahkandit beds and rest directly on rocks of the Rampart series.

Kenai series.—Next above the Mission Creek rocks, and not always readily distinguishable from them, is a great thickness of rather loosely consolidated conglomerates, shales, and sandstones, generally greenish in color, which are the coal-bearing rocks of the region; they everywhere contain plant remains, and rest unconformably upon the older rocks. They have, however, been folded to a certain extent, and stand upturned at angles of 20° to 60°. They are supposed to be of Eocene Tertiary age.

Later Tertiary beds.—Other and more recent Tertiary beds have been observed, generally in the more open country of the Lower Yukon, which have little economic importance, though they sometimes contain thin lignitic seams. They are variously known from the localities where they have been observed, as the Nulato sandstones and Twelvemile and Porcupine beds, the two last named being assumed to belong to the same series. . . .

As regards the occurrence of the gold-bearing formations, the Birch Creek, Fortymile, and Rampart series described above, they constitute a belt which extends about 500 miles in a general northwest-southeast direction, but there are indications that the actual extent of these exposures may be twice as great.

The best-known exposures of these rocks occur along the northeastern flanks of a broad belt of fundamental granites and crystalline schists which apparently form the central nucleus or backbone upon which they rest. This belt is known in a general way to extend up the Tanana River from near its mouth southeastward across the White River below the Donjek. In the latter region C. W. Hayes reports quartzites and limestones resembling the Birch Creek and Fortymile series on the southern flanks of the granite, but the width of the belt, and whether there is any considerable extent of the gold-bearing formations along its southern flanks, is as yet unknown. It may not improbably extend into the high range of the Tanana, of which Mount McKinley is the culminating point and in which the Kuskokwim and Sushitna Rivers of western Alaska take their rise, for from the reports of Moravian missionaries and of the traveler Dickey it appears that gold occurs in the sands of each of these streams. To the westward the granite backbone appears to pitch gently downward, as its surface area narrows, and no exposures are known west of the Yukon River. It is probably not a continuous mass of granite on the surface, but contains smaller areas of the later rocks folded in with it. East of the international boundary the area in which the granite occurs apparently widens, but its exposures are less continuous, the overlying rocks not yet having been worn away. One granitic axis appears to extend eastward from the Fortymile district through the Klondike region in a nearly east-west direction, which is that of the prevailing strike of the sedimentary rocks. The Canadian geologists report a second granite axis on the Dease River just below Dease Lake, which may belong to the older granites, though they do not make the same distinction that Spurr does between the older granites and the later intrusive rocks.

Rocks of the various gold-bearing series above the granite are reported at the following localities: Their first appearance, to one ascending the Yukon from the sea, is near the mouth of the Nowikakat. From here up to the Tanana River, rocks of the Birch Creek series outcrop frequently along the river, when not concealed by Tertiary sandstones and conglomerates, and the range of low mountains on the north side and parallel to the river is probably formed of these and Fortymile rocks. About 3 miles above the mouth of the Tanana, granite is exposed on an island in the Yukon, and 12 miles higher calcareous quartzitic schists of the Fortymile series appear under the Tertiary conglomerates. From the mouth of the Tanana up to Fort Hamlin, at the lower end of the Yukon Flats, the river runs in a canyon-like channel, known as the Lower Ramparts, cut through a low range of mountains which consist principally of the dark greenish and reddish rocks of the Rampart series, except where these are buried under Tertiary conglomerates. The latter rocks occur immediately above the exposures of Fortymile rocks, and again from Mynook Creek up beyond the mouth of Hess Creek. Higher

up on these streams the Rampart rocks come to the surface, and the Fortymile rocks are supposed to be uncovered at their very heads. Between the two areas of Tertiary rocks the Rampart rocks occupy a belt 15 to 20 miles wide along the river, and are cut by great dikes of intrusive granite.

From Fort Hamlin up to near Circle City, a distance, neglecting curves, of about 200 miles, the river flows through a perfectly flat region covered by fine silts and gravels, known as the Yukon Flats, in which no outcrops of solid rock have been observed. In the Birch Creek district, around the headwaters of Birch Creek and southwest of Circle City, the Birch Creek series occupy a broad area; their general strike is east and west, curving at either end to the northward, and the prevailing dip is between 5° and 30° to the south. There is, however, evidence of a northern dip as well, and the Fortymile schists and marbles rest upon them along the trail to Circle City. Marbles, probably belonging to the Fortymile series, are also reported in the hills between Birch Creek and the Tanana to the southward.

At the crossing of Birch Creek by the trail from Circle City, and along the Yukon River for 30 or 40 miles above the Yukon Flats, rocks with the characteristic dark coloring of the Rampart series are exposed. From these up to the mouth of Mission Creek rocks of the Tahkandit, Mission Creek, and Kenai series occupy the banks of the river. On Mission Creek itself only these later formations are found, but the gold in the gravels is supposed to come from the conglomerates of the Mission Creek series, which contain pebbles of the older rocks. On American Creek, the main branch of Mission Creek which comes in from the south, the dark rocks, shales, limestones, and tuffaceous beds which form the bed-rock are supposed to belong to the Rampart series, which also occur along the Yukon River from 5 to 10 miles above Mission Creek to within 25 miles of the mouth of Fortymile Creek. Above this to some distance above Fortymile Creek the river runs in beds of the Mission Creek series.

It is in the Fortymile district and the adjoining mining district on tributaries of Sixtymile Creek that the relations of the different gold-bearing series are best seen. Here there is an east-west axis or backbone running parallel to the upper part of Fortymile Creek and along the divide between it and Sixtymile Creek, with quartzite-schists of the Birch Creek series resting immediately on it both to the north and to the south. Above these on either side are the marbles and alternating schists of the Fortymile series. Fortymile Creek below the forks runs for a considerable part of its course along the junction between these two series, on the northern flank of the anticline. Dikes of various eruptive rocks, including intrusive granite, are very abundant, especially on the South Fork. On the upper part of this fork are green tuffs and slates of the Rampart series, overlain unconformably by conglomerates, sandstones, and coaly shales of the Mission Creek series. Both the South Fork and Sixtymile Creek are supposed

to head in a backbone of granite around Sixtymile Butte, which is surrounded by quartzite-schists of the Birch Creek series. These regions lie partly in American, partly in Canadian territory.

The Canadian area has not been studied by American geologists, except in wayside observation along such routes of travel as necessarily lay through it. The Canadian geologists, on the other hand, did not in their earlier and published observations recognize any subdivisions in the older rocks such as have been made by Spurr. Hence it is not possible to attempt even a proximate outline of the Canadian gold-bearing rock formations. General geological data and local discoveries of gold-bearing gravels indicate that the gold-bearing area is very large, and may be roughly defined as reaching from Dease River to the boundary, with a width of 200 to 300 miles or more. The recent enormously rich discoveries have, however, been confined to a more limited area around the Klondike and Stewart Rivers. It is assumed that the east-west uplift of fundamental granite and overlying rocks extends eastward into the Klondike district, and that a second uplift in a southeasterly direction extends from upper Fortymile Creek toward the valley of Stewart River.

Spurr noted outcrops of the schistose quartzites of the Birch Creek series for a large part of the distance from the mouth of Fortymile Creek up to the junction of the Pelly and the Lewes at Fort Selkirk; also granites at various points, in some cases schistose like the fundamental granite, in others fresh and massive-like intrusive granite. There were also occasional belts of marble belonging to the Fortymile series, notably one 5 or 6 miles above the mouth of Sixtymile Creek, not far from that of Stewart River. These observations afford a rough section across the belt of crystalline schists mentioned by the Canadian geologists as stretching eastward and southeastward along the upper Pelly and adjoining streams and across to the Frances River. Along the eastern edge of the crystalline belt they also recognized rocks of a general greenish color, made up largely of altered volcanic rocks, which would answer to the description of the Rampart series. Similar rocks were also noted at various points on the Lewes above its junction with the Pelly, notably in the Seminow Hills near the Big Salmon River, which may represent the development of the Rampart series on the south flanks of the crystalline belt. . . .

The hills surrounding the gulches of the Little Mynook and Hunter Creeks, on the Lower Yukon, are formed of rocks of the Rampart series. The bed-rocks are of diabase, tuffs, impure shales, and quartzites, and in the bottoms of the gulches there is from 10 to 20 feet of gravel. The gravel consists in part of angular fragments of rocks that form the walls of the gulch, in part of waterworn pebbles of Birch Creek schist, schistose granite, and other rocks. The gold is generally in rounded, bean-shaped grains and nuggets, and less frequently in unworn par-

ticles. This points to a two-fold origin of the gold, as derived in part from the rocks immediately about and in part from distant and older rocks, which may have been worn down, possibly along an old seashore, into terrace gravels, and then by subsequent erosion brought into the present stream beds. Further exploration in the hills to the south may disclose the true source of these pebbles and of the gold that accompanies them. On American Creek, in the Mission Creek district, the gold-bearing placers are also derived from rocks of the Rampart series—quartzitic schists, serpentines, and chloritic rocks—and the gold is said by Spurr to have been derived mainly from the schistose zones in the bed-rock.

The richest gravels have been found in the Birch Creek and Fortymile districts. In the entire Birch Creek district, which lies south of Circle City, and on Miller, Glacier, Poker, and Davis creeks of the Fortymile district, near the international boundary, the bed-rocks are always the quartzite-schists of the Birch Creek series, containing veins of quartz. The gravels rest, as a rule, directly on the schist, though in some cases, as on Harrison and Eagle creeks in the Birch Creek district, there is clay beneath the gravels, and the gold as a rule does not extend into the bed-rock but occurs chiefly at the top of the clay. Generally, however, the schist is rotted and reddened from oxidation for a few inches to several feet below the surface, and in this part the gold has settled into the cracks and joints. The pay gravels lie mostly next the bed-rock, in an average thickness of perhaps 2 feet, though sometimes up to 10 feet, while the overlying gravels average 8 or 10 feet, with a maximum of 25 feet. In the gravels the schist is in quite large, flat fragments, and the quartz is in bowlders of varying size. The schist fragments lie flat, and are mixed with sand, showing that the sorting action of running water has not been carried far. In the concentrates from the sluice boxes the heavier minerals associated with the gold—galena, magnetite, limonite, hornblende, and garnet—are in each case such as are found in the neighboring schists, and the nuggets of gold often have pieces of quartz still adhering to them. All these facts are evidence that the gold is derived from rocks in the vicinity, and is not brought from a great distance, perhaps by glaciers, as some erroneously suppose.

The rocks of the Fortymile series in the Fortymile district, as already stated, form the west bank of Fortymile Creek, and south of the South Fork cross the divide between Franklin Gulch and Napoleon Creek, where they are overlain by green slates of the Rampart series, which in turn are overlain by conglomerates of the Mission Creek series. In Franklin Creek the bed-rocks are marbles interbedded with mica- and hornblende-schists; the gravel contains fragments of marble, quartzite, mica-schists, and vein quartz. At one point a quartz vein is found in the bed-rock, and below it native silver has been found in the gravels, which apparently came from this vein. It is the schistose rocks that

mostly carry the gold, as the marbles do not show much evidence of veins. In this gulch are two levels; the higher one, at the head of the gulch, had not been worked, while the pay gold had been found mainly at the lower level, near the mouth of the gulch.

Chicken Creek, so-called because its gold occurs in grains the size of chicken feed, drains a wide area toward the Ketchumstock Hills to the southwest, and the actual source of the gold is less readily defined. The gravel contains fragments of granite, quartzite, schist, and marble.

On Napoleon Creek conglomerate forms the bed-rock near the mouth. The gravels contain fragments of quartzite, vein quartz, hornblende-granite, and various eruptive rocks, and the source of the gold is assumed to be the conglomerate, which is made up of fragments of the older rocks, for the rocks higher up the gulch above the conglomerates have not been found to carry much gold.

The most trustworthy reports from the Klondike region indicate that the exceptionally rich placer gravels thus far found occur in side valleys entering the main Klondike Valley from the south, such as Bonanza, Eldorado, and Hunker creeks, and in some gulches across the divide tributary to Indian or Stewart rivers. No gold in paying quantities had been found on the Klondike itself. The placer deposit generally consists of 10 to 15 feet of frozen muck and decayed vegetation at the surface, then a gravel bed that rarely pays; below that a clay selvage, under which is pay dirt from 1 to 5 feet in thickness resting on the upturned edges of the schist, from which it is separated by a clay selvage. The pay streak or bottom of the old channel is usually very regular and straight, not following the bends of the present stream."

3. *Geological nomenclature.*—The general secretaries of the International Geological Congress have made a report of the action of the congress relative to geological nomenclature, of which the following is a translation:

The seventh Geological Congress, which convened at St. Pétersburg on the 17th to the 24th of August 1897, considered, according to the announcement of the circulars of the committee of organization, the questions of stratigraphical classification and nomenclature.

After discussing the question in the session of August 18 (30) the Congress passed the following votes:

"The Congress is of the opinion that the historic method should be adopted in seeking to make the nomenclature more natural."

"The council is charged with naming a committee for the study of the principles of classification in the spirit of the first clause."

The council thereupon decided to compose the committee of a number as restricted as possible, but, in order not to deprive it of the coöperation of geologists capable of rendering assistance in the work, added certain consulting members. The following committee was appointed.

Members effectifs: M. M. Barrois, Ch., Capellini, G., Hughes, Thomas, Renevier, E., Tietze, E., Tschernyschew, Th., Williams, H. S., v. Zittel, K.

Members consultatifs: Choffat, P., Clark, W., de Cortazar, D., Davis, W. M., Dawson, G., Déperet, Ch., Frech, Fr. Griesbach, C., Karpinsky, A., Kayser, E., de Lapperent, A., Martin, K., Mayer-Eymar, Ch., Nathorst, A., Nikitin, S., Stephensen, G., De Stefani, G., Taramelli, T., Uhlig, V., Van den Broeck, E., Walcott, Ch., Woodward, Hor.

In the session of August 20 (Sept. 1), which was devoted to the question of the stratigraphic nomenclature, the Congress, after the discussion of the propositions of Messrs Bittner, Frech, Karpinsky and Tschernyschew, accepted the following propositions:

I. The introduction of a new stratigraphic term in the international nomenclature ought to be based upon well established scientific need, justified by some particular reasons. Every new appellation ought to be associated with some distinct characteristic—both stratigraphical (batrologique) and paleontological—of the deposits to which it is applied; at the same time it ought to be founded upon facts observed not in a single section only, but over a more or less extended area.

II. The appellations applied to a terrain in a particular sense cannot be employed in another sense.

III. The date of publication decides the priority of stratigraphic names applied to the same beds.

IV. For small stratigraphic subdivisions sufficiently well characterized paleontologically, in case of the creation of new names, it is preferable to take the most important paleontological peculiarities as a basis. Geographic or other names should not be employed except for sections of some importance including several paleontological horizons, or where the terrain cannot be characterized paleontologically.

VII. Names badly formed, from an etymological point of view, are to be corrected without excluding them, on that account, from use in the science.

As to the following two propositions:

V. "It is preferable, in the case of various stratigraphic terms already existing in the literature, to substitute the words superior, median and inferior for those applied to sections and series.

VI. "When a term given to a whole series of beds is to be restricted in meaning to a part only of the beds, it should not be applied except to the beds which are paleontologically the more characteristic,"—it was decided to refer them for consideration to the stratigraphic committee elected at the session of August 18th (30).

Concerning the place of re-unions of the stratigraphic committee, the Congress decided that the committee should itself determine place of meeting, taking consideration of the re-unions of the various geological societies.

The committee elected Professor Renevier president, and Mr. Lugrom secretary of the committee.

The report is signed by the general secretaries, MM. Th. Tschernyschew and C. de Vogdt. H. S. W.

4. *The Development of Glyphioceras and the Phylogeny of the Glyphioceratidæ;* by JAMES PERRIN SMITH. (Proc. Cal. Acad. Sci., Series III, vol. i, No. 3, pp. 105–129. With three plates. 1897.)—The author has traced out and illustrated the stages of growth of this early goniatite from actual specimens of *Glyphioceras incisum* Hyatt from the Lower Carboniferous formation in northern Arkansas. The following summary is given of the ontogeny of the genus Glyphioceras.

"Glyphioceras in its ontogeny goes through the following stages: phylembryonic, protoconch, representing the primitive cephalopod; ananepionic, Silurian nautiloid; metanepionic, Anarcestes of Lower Devonian; paranepionic, Tornoceras of Middle Devonian; neanic, Prionoceras of Upper Devonian and Carboniferous, showing gradual transition through ana-, meta-, and paraneanic, and a gradual change from Prionoceras to Glyphioceras in the late adolescent and early adult stages. Prionoceras is undoubtedly the family radicle, and Brancoceras is a side-branch, since Glyphioceras does not go through any stage corresponding to the latter genus. Gastrioceras comes from Prionoceras through Münsteroceras) by somewhat narrowing the whorl and division of the ventral lobe. Glyphioceras comes directly from Prionoceras by narrowing the umbilicus so as to conceal most of the inner whorls and by division of the ventral lobe.

The division of the subfamily Glyphioceratidæ into Brancoceras, Prionoceras, Pericyclus, Glyphioceras (subgenus Münsteroceras), Gastrioceras, Paralegoceras, is quite proper for phylogenetic reasons.

According to Steinmann the Ceratitidæ of the Trias are descended from Gastrioceras, and the Tropitidæ from Pericyclus, but neither of these groups goes through stages of growth corresponding to these genera. Tropites does, however, go through a Prionoceras stage, and later it resembles closely Gastrioceras, but it already has the Tropites keel before the ventral lobe is divided. It then descends from the Glyphioceratidæ, but directly from the radicle and not through any modified form. But it is quite likely that some of the genera assigned to the Tropitidæ do descend directly from other members of the Glyphioceratidæ. H. S. W.

5. *Brief notices of some recently described minerals.*—RASPITE. A new tungstate of lead, $PbWO_4$, from the Broken Hill mines in New South Wales, described by C. Hlawatsch. It occurs in small brownish yellow transparent crystals of tabular habit; these belong to the monoclinic system. The hardness is 2·5 and the luster adamantine; an approximate determination of the refractive index gave the unusual value 2·6. An analysis by F. P. Treadwell yielded:

WO_3	PbO	Fe_2O_3, MnO	
49·06	48·32	1·43	= 98·81

Raspite, associated with stolzite, occurs with decomposed galena

in limonite. It is named after Rasp, the discoverer of the Broken Hill mines.—*Ann. Mus. Wien.*, xii, 1897.

LEONITE. A mineral closely related to blödite, obtained from the Prussian salt mines of Westeregeln and Leopoldshall. It is characterized by its containing potassium in place of sodium, its formula being $MgSO_4 . K_2SO_4 + 4H_2O$. It occurs in monoclinic crystals which are now described by C. A. Tenne, the existence of the mineral having been earlier recognized.—*Zs. Geol. Ges.*, xlviii, 632.

TRIPUHYITE. A new antimonate of iron from Tripuhy, Brazil, described by E. Hussak and G. T. Prior. It occurs in microcrystalline aggregates of a dull greenish yellow color. The streak is canary-yellow; the specific gravity 5·82. An analysis gave the following results:

Sb_2O_5	FeO	CaO	SiO_2	Al_2O_3	TiO_2	*undet.*
66·68	27·70	0·82	1·35	1·40	0·86	1·19=100

The above corresponds to the formula, $2FeO . Sb_2O_5$.—*Min. Mag.*, xi, Dec., 1897.

GERSBYITE. A hydrous aluminum phosphate near lazulite in composition, and resembling it in its fine blue or bluish green color. It occurs in grains and small crystals imbedded in the cyanite of a schistose damourite-quartzite. Five analyses give amounts of water varying from 7·19 to 15·40 per cent. It is named by Igelström from the village Gersby, near which it is found in the Ransäter parish, Wermland, Sweden. The same region has afforded an imperfectly investigated mineral called by Igelström MUNKRUDITE. It seems to be near svanbergite in composition.—*Zeitschr. f. Kryst.*, xxviii, 310, 1897.

LANGBEINITE. An anhydrous potassium-magnesium sulphate, $K_2Mg_2(SO_4)_3$, described by Luedecke from Westeregeln and other points in the Prussian salt mines. It is remarkable as crystallizing in the tetartohedral class of the isometric system, the crystals being highly modified and characteristic in form. The specific gravity is 2·83. The fresh salt is colorless and without taste. The analyses made agree closely with the above formula. —*Zs. Kryst.*, xxix, 255.

6. *Handbuch der Mineralogie*, von Dr. CARL HINTZE. Erster Band, 160 pp. Elemente, Sulfide, Oxyde, Haloide, Carbonate, Sulfate, Borate, Phosphate. pp. 1–140. Leipzig (Veit & Comp. 1898). The appearance of the first part of Volume I of Hintze's Mineralogy is encouraging, as showing that notwithstanding the labor which the author has put upon the nearly two thousand crowded pages of the second volume already completed, his energy is not exhausted, and at no very distant date we may hope to see the entire work completed. The present part is devoted to the native elements, beginning with carbon and extending nearly through the discussion of iron.

7. *Ueber Alter, Lagerungsform und Enstehungsart der Periadriatischen granitkörnigen Massen.* Habilitationsschrift, DR. WILHELM SALOMEN.—This paper contains a general review of the

facts connected with the intrusion and method of occurrence of a number of areas of igneous rocks, well known from the large amount of geological literature bearing on them, such as the Adamello and Riesenferner groups and Predazzo and Monzoni. It contains a number of new facts and will prove of interest and value to those whose studies lead them to look up the literature dealing with the geology of these regions.—*Tschermak's Min. Petr. Mitth.*, xvii, 1897. L. V. P.

8. *Petrology for Students, an introduction to the study of rocks under the microscope;* by ALFRED HARKER. Second ed., 12mo, pp. 334 (University Press, Camb.).—We have had occasion to notice previously the appearance of this excellent little manual. The fact that it has now run into a second edition shows that it was needed. The new edition, in addition to a thorough revision, contains some new matter, especially references to American localities and rock types, which will render it more useful in this country.

L. V. P.

III. BOTANY AND ZOOLOGY.

1. *Pflanzenphysiologie. Ein Handbuch der Lehre vom Stoffwechsel und Kraftwechsel in der Pflanze;* von DR. W. PFEFFER, Professor an der Universität Leipzig. Erster Band. Stoffwechsel. Leipzig, 1897.—This is the first volume of the revised edition of a work which was issued in 1880, when its author was a professor in Tubingen. During the period of almost twenty years which have elapsed since the first date, Professor Pfeffer has continued to enrich every department of vegetable physiology. His communications have touched some fields which lie on the border between physiology and other sciences, while in the domain of physiology itself the contributions have been important and, in at least one part, revolutionary in their effects. The peculiar relations of motile protoplasm to chemical agents and to tinctorial reagents, have been made so clear that the work of further experimenting in this field promises substantial results. In other branches of experimental morphology, also, Professor Pfeffer has opened up new paths.

For this revision students have been waiting with impatience. Under the condition of extreme specialization which now prevails, and which is likely hereafter to characterize all scientific research, an occasional presentation of a balance sheet by a critical master is an absolute necessity. It was expected that in this complete revision would be given such a balance sheet, contrasting the real contributions, however trivial, with the untrustworthy and unverified results which clamor for publication. This hope has not been disappointed. All questions have been discussed impartially and decisions have been made without prejudice. Therefore, as might be looked for, this treatise is a distinct contribution in itself to the department of vegetable physiology. Professor Pfeffer has always paid much attention to the dynamics of vegeta-

ble life, and this is shown even in this part, which is devoted to the appropriation and distribution of matters by plants. The remaining volume, to be devoted to the relations of plants to the forces, will possess even a higher degree of interest than the present. We trust that Professor Pfeffer will give his consent to the translation into English of this second edition of his valuable handbook, in order that it may reach a wider circle of thoughtful men in many departments of thought. G. L. G.

2. *Permeability of the bark of tree-trunks to atmospheric gases.*—M. Henri Devaux, Comptes Rend., Dec. 6, 1897, has made use of a simple apparatus for determining some of the relations of the living peripheral layer in the trunks of large trees to the gases of the atmosphere. He cements, by means of wax, a small funnel to the bark of the tree to be examined, fills the funnel with water, and then diminishing the pressure, observes the bubbles which escape into the water. Apertures on large trunks are virtually lenticels like those of small branches, and from these trunk lenticels air escapes abundantly under the conditions noted. In some cases there is a marked difference between the two sorts of lenticels, those of the trunk being less permeable than those of the twigs.

Not only do respiratory exchanges take place through these apertures but through accidental wounds, however small. In two instances the impermeability of the lenticels was practically complete, namely, in *Picea excelsa* and *Populus alba*. Even under great exhaust no bubbles were withdrawn from the bark of these. The experiments were conducted in October. Perhaps a different condition of affairs as to permeability prevails at other seasons of the year.

One of the most interesting observations made by the investigator was in regard to the influence exerted by lichens in occluding the lenticels. Even when the lichen on the trunk is crustaceous, and closely appressed, it does not close the pathway of the gases to and fro. No report is yet given as to the character of the gases thus withdrawn from the plants.

Two gaps appear to be unfilled in this account of the permeability of the bark of tree-trunks: the recorder does not make it clear that he eliminated errors arising from the contained air of the corky layer; and, secondly, no proof appears that the gas escaping in bubbles came wholly from the living tissues within the corky layer. Nevertheless this application of an old method is interesting and may suggest further steps in the same direction.

G. L. G.

3. *Lessons with Plants: Suggestions for Seeing and Interpreting some of the Common Forms of Vegetation;* by L. H. Bailey. Pp. xxxi + 491, figs. 446. New York, 1898 (The Macmillan Company; $1.10).—The purpose of Professor Bailey's book is not to teach the science of botany but to serve as a guide in the "nature-study" of plants, and it is intended for the use of beginners in the secondary schools. In each chapter some

characteristic feature of plant-structure or plant-life is described from illustrative material, special emphasis being laid on those points which can be directly observed. The facts are presented in a popular yet scientific manner and are usually supplemented by suggestive questions or directions for the pupil. The numerous figures, which were drawn from nature by Professor Holdsworth, add very much to the value of the book. A. W. E.

Garden-making. Suggestions for the utilizing of Home Grounds, by L. H. BAILEY, aided by L. R. Taft, F. A. Waugh, and Ernest Walker. New York, 1898 (The Macmillan Company).

4. *Catalogue of the Madreporarian Corals in the British Museum.* Vol. iii, *Montipora and Anacropora;* by HENRY M. BERNARD. London, 1897, 4to., 192 pages, 34 plates.—This handsome volume is devoted mostly to the genus *Montipora*, which is one of the most extensive genera of reef-corals, and also one in which the species are very hard to determine or define, owing to their great variability, as well as to their large numbers. In this work the author recognizes 135 species, of which 81 are described as new. They were represented by 450 specimens, but, as the author states, many of the species are only represented by a single specimen, sometimes only a fragment. Very likely a larger series of specimens might serve to unite some of these forms, but doubtless many more remain to be discovered.

The descriptive part of the work is preceded by a historical sketch of the knowledge of the genus, and of the various views that have prevailed, as to its affinities. Its structure is also discussed, as well as the distribution of the species. No species is known from the Atlantic Ocean, but they are everywhere abundant in the warmer parts of the Indo-Pacific region. The new species are beautifully illustrated by photographs reproduced by the collotype process, and also by greatly enlarged lithographic figures of one or more calicles and the surrounding structures.

Of *Anacropora*, six species are recognized and described. The work is thoroughly well done. A. E. V.

5. *A Text-book of Zoology;* by T. JEFFREY PARKER and WILLIAM A. HASWELL. 2 vols., 8vo, 1402 pages, 1171 cuts. London: Macmillan & Co., 1897.—This is in every way an admirable text-book of zoology, and exceedingly well adapted for advanced students. Yet it is written so clearly that it can be used even by beginners. The illustrations are profuse and have been selected with excellent judgment from the most reliable sources. The subjects are taken up in accordance with their sequence in the classification adopted, each of the larger groups having a section or chapter devoted to it. At the end of the second volume there are brief sections devoted to geographical distribution, the philosophy of zoology, and the history of zoology, which add greatly to the value of the work.

In the system of classification adopted, perhaps the most unusual feature is the large number of primary groups or phyla. Of these there are twelve, viz: Protozoa, Porifera, Cœlenterata,

Platyhelminthes, Nemathelminthes, Trochelminthes, Molluscoida, Echmodermata, Annulata, Arthropoda, Mollusca, Chordata. To many zoologists this number of primary groups will undoubtedly seem unnecessarily great. But it is true that it enables one to define the groups more clearly. Perhaps the Nemathelminthes and Trochhelminthes are the least satisfactory of the vermian series. A number of groups, allied to one or the other of these, are treated as appendages of the former, with uncertain affinities. Such are the Chætosomidæ, Echinoderidæ, etc. The Nemertinea are, in the same way, appended to the Platyhelminthes. The second volume is devoted almost entirely (582 pages) to the Chordata.

The Adelochordata are included in the Chordata, somewhat doubtfully, as a sub-phylum. The objections to this view of the affinities of *Balanoglossus*, etc., are, however, pretty fully stated.

The number of orders recognized in some of the classes is unusually large. Of existing Aves, 26 orders are adopted. On the other hand, the number of mammalian orders is but 12, and of Pisces but 11, but many zoologists will be disposed to consider several of the so-called orders of birds as of less value than many of the "sub-orders" of fishes or mammals. Of Insecta, only 8 orders are recognized, the Neuroptera and Orthoptera being adopted with their early significance and extent.

But these are matters upon which there is still great differences of opinion and are of only secondary importance in a text-book of this character. A. E. V.

IV. Miscellaneous Scientific Intelligence.

1. *United States Coast and Geodetic Survey.*—The Report of W. W. Duffield, the Superintendent of the United States Coast and Geodetic Survey for the year ending June, 1896, has recently been issued. In addition to the usual subject-matter and charts, among which we note particularly a general one of Alaska, there are a series of twelve appendices. Of these is especially to be mentioned one on terrestrial magnetism, by C. A. Schott, Assistant. This, in continuation of earlier publications on the same subject, gives the distribution of the magnetic declination in the United States for the epoch January 1st, 1900. The text and tables are accompanied by three charts, the first and third giving the distribution of the isogonic lines for the United States and Alaska respectively, for the epoch mentioned; the second showing the annual change of magnetic declination from 1895 to 1900.

2. *Annals of the Astronomical Observatory of Harvard College.* Edward C. Pickering, Director. Volume XLII, Part I. Cambridge (John Wilson & Son, University Press), 1897.—This publication, just issued, contains a record of observations made at the Blue Hill Meteorological Observatory in 1896, under the direction of A. Lawrence Rotch. This record with Tables I to

VII occupies pages 1–27, following which are two appendices. Appendix A is devoted to a study of special cloud forms, by A. E. Sweetland, especially as regards their relations to cyclones and anti-cyclones, to precipitation, and temperature changes. Appendix B, by S. P. Fergusson, gives an interesting discussion of the results obtained by the exploration of the upper atmosphere by means of kites. The special forms of kites are described, as also the registering meteorological apparatus carried by them. The results obtained thus far show the value of this new method of meteorological research.

3. *L. Rütimeyer-gesammelte kleine Schriften allgemeinen Inhalts aus dem Gebiete der Naturwissenschaft-nebst einer autobiographischen Skizze*, herausgegeben von H. G. Stehlin. Band I, pp. 1–400, portrait, 1 map and 6 figs.; Band II, pp. 1–456, 1 fig. Basel (Georg et Cie), 1898.—In these two volumes are collected the addresses and smaller essays of the Swiss naturalist Rütimeyer, who is best known for his works on vertebrates, recent and fossil, but chiefly mammals, and who died in 1895. They are mainly written in popular style, and some of them are still interesting reading, though reflecting the views of the older school of naturalists. The following are a few of the titles of the papers: On the form and history of the vertebrate skeleton; on the historic method in paleontology. The limits of the animal world, a discussion of Darwin's theory. On the nature of progress in the organic creation. From the sea to the Alps, descriptions of the structure, form and color of our continent upon a section from England to Sicily. A sketch of the history of glacier-studies in Switzerland. Sketches of the lives of Agassiz, of Charles Darwin, of Bernhardt Studer, etc.

His more important scientific works were on Ruminants (Bos, Deer, Equidae, etc.), and on the fossil turtles. H. S. W.

4. *Transactions of the American Microscopical Society.* Edited by the Secretary. Volume xix, pp. 207, Buffalo.—The volume just issued, bearing date of December, 1897, contains the proceedings of the American Microscopical Society for the twentieth annual meeting, held at Toledo, Aug. 5th, 6th and 7th, 1897. It includes an address by the President, E. W. Claypole, entitled, "Microscopical Light in Geological Darkness," which discusses some of the ways in which the recent work with the microscope, especially in petrography, has served to throw light upon obscure geological problems. A series of valuable papers follow, chiefly on biological subjects.

5. *Physikalisch-chemische Propädeutik;* von H. Griesbach. zweite Hälfte, 2 Lieferung, Leipsic, 1897 (Wilhelm Engelmann), —Two previous parts of this valuable text-book on physical, chemical and biological science have already been noticed in this Journal (vol. ii, p. 450). The present part, comprising pages 593–944, maintains the high standard of excellence and fullness that characterized the earlier issues. The scope of the work has been somewhat enlarged beyond the original plan,

so that another part will appear, which is promised during the course of the present year. H. L. W.

6. *Bibliography of the Metals of the Platinum Group. Platinum, Palladium, Iridium, Rhodium, Osmium, Ruthenium.* 1748–1896. By JAS. LEWIS HOWE, pp. 318, Washington, 1897, Smithsonian Miscellaneous Collections, 1084.—This exhaustive bibliography has been prepared by Prof. J. L. Howe under the auspices of the Committee of the American Association having charge of indexing chemical literature. Prof. H. Carrington Bolton is chairman of the committee.

OBITUARY.

WILLIAM A. ROGERS was born at Waterford, Conn. on the 13th of November, 1832. He entered Brown University in 1853 and graduated in 1857. In 1859 he was elected Professor of Mathematics in Alfred University, N. Y. and remained there until 1870. During this period he spent a year as a special student in the Harvard College Observatory and eighteen months in the U. S. Navy. He built and equipped the Alfred Observatory in 1865, and the subsequent year being appointed Professor of Industrial Mechanics in Alfred, he spent several months in preparation for his new duties in the Sheffield Scientific School. In 1870 he was appointed assistant, and in 1875 Assistant Professor in the Harvard Observatory, where he remained until 1886, when he accepted the Professorship of Astronomy and Physics in Colby University, Waterville, Me. In 1897 he was elected Babcock Professor of Physics in Alfred University, expecting to enter upon his new duties on April 1st, 1898. Professor Rogers was a man of remarkable powers as an observer and of exceptional acuteness as an experimenter. His work at the Harvard Observatory in the former line ranks with the best work done there; and he stood easily at the head of the metrologists of this country in the line of linear measurement. He was elected to the American Academy in Boston in 1873, a Fellow of the Royal Microscopical Society of London in 1880, President of the American Microscopical Society in 1887, Vice-President of the American Association in 1883 and a member of the National Academy of Sciences, in 1885. In 1880 Yale University gave him the degree of A.M., in 1886 he received that of Ph.D. from Alfred University and in 1892 Brown University conferred upon him the degree of LL.D. He died in Waterville, March 1st, 1898. His list of published papers includes about 70 titles. G. F. B.

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